Management Framework of Software Product Line Engineering: Real Options Perspective

BY

Khalid Mohammed Hussein Al-Kahsah

May, 2012

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A Thesis Presented to the
DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

COMPUTER SCIENCE

May, 2012

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN- 31261, SAUDI ARABIA

DEANSHIP OF GRADUATE STUDIES

This thesis, written by **Khalid Mohammed Hussein Al-Kahsah** under the direction of his thesis advisor and approved by his thesis committee, has been presented to and accepted by the Dean of Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **COMPUTER SCIENCE**.

Thesis Committee

Thesis advisor
Dr. Sajjad Mahmood

Member
Dr. Mohammad Alshayeb

Department Chairman
Dr. Adel Fadhl Ahmed

Member
Dr. Moataz Ahmed

Dean of Graduate Studies
Dr. Salam A. Zummo

Date
12/1/13

I dedicate this modest work to Allah Almighty for his grace and blessing

I ask him to accept this work and to make it useful

Then I dedicate it to:

Saba the homeland and the human .. The love and the hope

My parents sourcing tender and the reason of my being

My brothers who I relied on them when adversity

My sisters' the headwaters of love and kindliness

My wife my life partner at the moments of happiness and sadness

My daughter who gives me the Permanent smile

My teachers who guide me to the right way

My friends the meaning of Permanent Fidelity

To all of them I dedicate this work with all of my love and appreciation.

ACKNOWLEDGMENT

I thank Allah (SWT) for granting me health, patient, guidance and determination to successfully accomplish this work.

I would like to express my deep appreciation to my thesis advisor Dr. Sajjad Mahmood, for his constant help, guidance, encouragement and invaluable support. Thanks are due to my thesis committee members Dr. Mohammad Alshayeb and Dr. Moataz Ahmed for their cooperation, comments and support.

I would like to thank King Fahd University of Petroleum and Minerals for sponsoring me throughout my graduate studies. I also would like to thank Ibb University which gives me the opportunity for completing my MSc degree in KFUPM.

Also, I would like to thank all my friends, for their help and support.

Finally, I would you like to thank my parents, my wife, daughter, brothers, and sisters who always support me with their love, patience encouragement and constant prayers throughout my study.

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THESIS ABSTRACT

Full Name : ***Khalid Mohammed Hussein Al-Kahsah***

Thesis Title : ***Management Framework of Software Product Line Engineering: Real Options Perspective***

Major Field : ***Computer Science***

Date of Degree : ***May 2012***

Software Product Line Engineering (SPLE) is an approach with an aim to move the software industry away from developing each system from scratch. The fundamental idea in SPLE is building systems from the common features rather than building new systems, because systems in a certain software domain have more commonalities than uniqueness. SPLE helps to identify common features among similar family of products into core assets and then reuse these core assets to develop subsequent applications. SPL development needs a collaborative process whereby organizations can balance the conflicting interests between high reusability demand and lower cost. This process needs to focus on how to achieve the required reusability level; and handle the uncertainties during the product line core asset development. Despite the large number of research and studies that touched SPL, there is a gap in the study of uncertainty associated with features selection in the core asset development. The main objective of this thesis is to address this issue by handling that uncertainty using the Real option Theory (ROT) concepts, which offers a systematic approach to identify and assess the issues that have an effect on the real options value, and help managers to make a decision under uncertainty. In this thesis we develop Software Product Line Engineering Management Framework (K-SPLEMF) for core asset development. Our framework identifies a method to classify an SPL features into features sets based on their dependencies relations; introduces a new matrix to calculate features and Features Sets Reuse Opportunities; prioritizes features and features sets in the SPL core asset development process by using ROT concepts. Furthermore, we analyze and discuss the results of the framework application on the SPL core asset development through case studies.

ملخص الرسالة

الإسم الكامل : **خالد محمد حسين الكحسه**

عنوان الرسالة : **إطار عمل إدارة هندسة خط إنتاج البرامجيات: منظور الخيارات الحقيقية**

التخصص : **علوم حاسب**

تاريخ الدرجة العلمية: **مايو 2012**

هندسة خط إنتاج البرامجيات (SPLE) هي نهج يهدف الى نقل صناعة البرامجيات بعيدا عن تطوير كل نظام من نقطة البداية. الفكرة الأساسية في (SPLE) هي بناء انظمة برامجيات من السمات (Features) المشتركة بينها بدلا من بناء انظمة جديدة، و ذلك لأن الأنظمة في مجال برامجيات معين لديها قواسم مشتركة اكثر مما يتفرد به كل نظام عن الاخر (يقصد بالسمات في هذه الدراسة المتطلبات الوظيفية؛ المتطلبات الغير وظيفية؛ الخدمات؛ متطلبات خط الانتاج القابلة لاعادة الاستخدام؛ و مميزات النظام).

هندسة إنتاج خطوط البرامجيات تساعد على تعريف السمات المشتركة بين مجموعة متماثلة من المنتجات كأصول أساسية (Core Assets) و التي يمكن أعادة استخدامها لتطوير و انتاج تطبيقات لاحقة. إن تطوير خط انتاج البرامجيات (SPL) يتطلب عملية تعاونية بحيث يمكن للمؤسسات تحقيق توازن بين تضارب المصالح لمطالب اعادة استخدام مرتفعة و تكلفة اقل. هذه العملية تحتاج للتركيز على كيفية تحقيق المستوى المطلوب من إعادة الاستخدام، و التعامل مع عدم التيقن (Uncertainty) خلال تطوير الاصول الاساسية لخط الانتاج. بالرغم من ان كثير من البحوث و الدراسات تناولت خطوط انتاج البرامجيات لايزال هناك فجوة في الدراسات التي تعالج مشكلة عدم التيقن المرتبطة بإختيار السمات عند تطوير الاصول الاساسية. الهدف الرئيسي لهذه الدراسة هو تناول هذه المسألة لمعالجة مشكلة عدم التيقن عند اختيار السمات لخط انتاج البرامجيات بإستخدام مفاهيم نظرية الخيارات الحقيقية (Real Options Theory (ROT)) و التي تقدم نهجا نظاميا لتحديد و تقييم المسائل التي يكون لها تاثير على القيمة الحقيقية للخيارات و مساعدة المسئولين على اتخاذ القرارات في حالات عدم التيقن.

في هذه الدراسة قمنا ببناء اطار عمل ادارة هندسة خط انتاج البرامجيات (Software Product Line Engineering Management Framework (K-SPLEMF)) لتطوير الاصول الاساسية. اطار العمل المقدم في هذه الدراسة يعرف طريقة لتقسيم سمات خط انتاج البرامجيات الي مجموعات سمات (Features Sets) بناء على علاقات الاعتمادية بينها؛ و يقدم مصفوفة جديدة لحساب فرص اعادة الاستخدام (Reuse Opportunities) للسمات او مجموعات السمات في خط انتاج البرامجيات؛ ايضا يعرف اولويات السمات او مجموعات السمات عند تطوير الاصول الأساسية لخط انتاج البرامجيات باستخدام مفاهيم نظرية الخيارات الحقيقية. علاوة على ذلك قمنا بتحليل و مناقشة نتائج تطبيق اطار العمل المقدم في هذه الرسالة على عملية تطوير الاصول الاساسية لخط انتاج البرامجيات من خلال حالات دراسية.

CHAPTER 1

Introduction

Over the last decade, the extensive uses of software have placed new demands on the software industry to enhance development productivity and reduce associated costs [1]. These expectations have led software engineers to apply the idea of reuse [2]. *Software Product Line Engineering* (*SPLE*) is an approach with an aim to move the software industry away from developing each system from scratch. Building systems from the common features rather than building new systems is the key idea in *SPLE* that is because in a certain software domain, systems have more commonalities features than private ones which give companies the ability to release product variants by adding new features [3]. *SPLE* helps to identify common features among similar family of products into core assets, and subsequent applications are developed by reusing these core assets [4, 5].

SPLE has potential to improve productivity and reduce time to market [6, 7]. As shown in *Figure 1.1*; fundamental to *SPLE* success is the need for a core asset which has high degree of reusability [8]. The organization can assemble the core asset base all at once before building any products (a proactive strategy) or incrementally as it introduces products (a reactive strategy) [9]. The reactive approach is like the agile approaches to conventional software where one or more product variations are analyzed and implemented on each development spiral [10].

A key challenge in *SPLE* is to find a right balance between reusability and cost involved in core asset development. The core asset development process needs to maximize the coverage of a product line domain within a budget and a given time frame. We believe that for *Software Product Lines* (*SPL*) to be a part of mainstream software engineering culture, organizations need strategies with low adoption barriers. There is a need that required a small upfront effort, incremental transition from current practices, and a rapid return on investment [10].

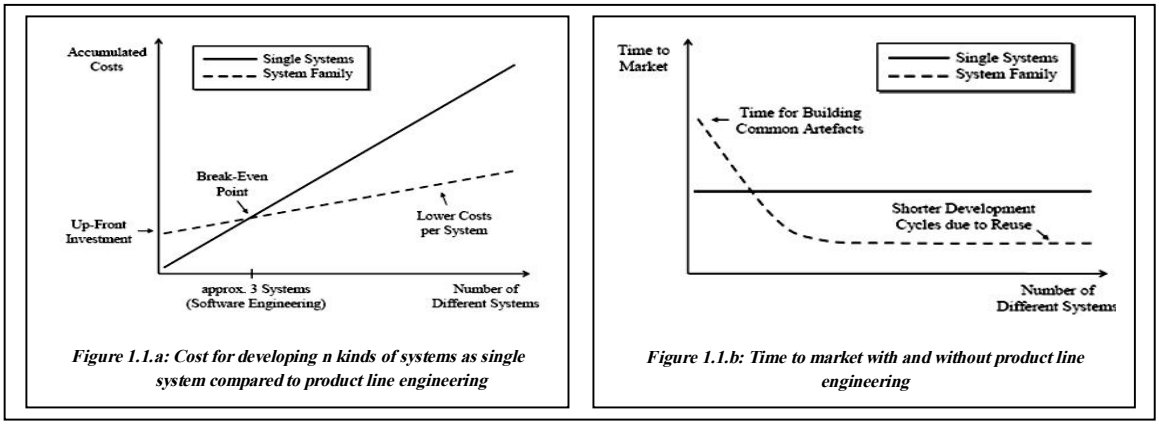

Figure 1.1: SPLE cost and time to market analysis [7]

In this thesis, we present a management framework for *SPLE* that provides quantitative information to evaluate reuse opportunity of software features. The framework helps in handling the uncertainties associated with software feature selection.

1.1 Motivation

SPL development needs a collaborative process whereby organizations can balance the conflicting interests between high reusability demand and lower cost. This process needs to focus on how to achieve the required reusability level; and handle the uncertainties during the product line core asset development.

In this thesis, we develop a management framework for *SPL* core asset development which helps a system analyst to (a) understand feature relationships and their dependencies; (b) quantifies *Reuse Opportunity* of features; and (c) handles the uncertainties within features selection by estimating the potential benefits of including features at different core asset development spirals. Furthermore, we consider the management of *SPL* core asset development from the perspective of *Real Option Theory* (*ROT*), which addresses uncertainty over time and handles selection of features during the development process.

1.2 Research Objectives

The main objective of the thesis is to address the key challenges associated with the *SPL* core asset development process by handling the uncertainty on *SPL* features selection. This main objective can be broken down into number of smaller objectives steps as follow:

- Analyze *SPL* features dependencies relations to classifying these features into a number of *Features Sets*.
- Develop a process to identify *Reuse Opportunities* for the *Features Sets* based on *SPL Marketing Product Plan* (*MPP*) and *Features Sets* dependencies relations.
- Identify *Development Priority* for *SPL Features Sets* in core asset development based on their *Reuse Opportunities*.
- Manage *Software Product Line* core asset development uncertainty based on the *Real Options Theory* concept.
- Analyze the impact of the framework on the *SPL* development based on case studies.

1.3 Research Contribution

As part of this thesis, we develop *Software Product Line Engineering Management Framework* (*K-SPLEMF*) for *SPL* core asset development. The main contributions of our work are:

- Identify a method to classify an *SPL* features into *Features Sets* based on their dependencies relations.
- Introduce a new matrix to calculate *SPL* features and *Features Sets Reuse Opportunities*.
- Prioritize features and features sets in the *SPL* core asset development process using *ROT* concepts.
- Analyze and discuss the results of the framework application on the *SPL* core asset development through the case studies.

1.4 Thesis Organization

The remainder of the thesis is organized into the following chapters:

- **Chapter 2: Literature Survey**

This chapter will go over the body of work that is relevant to our thesis by first covering the basic ideas and general concepts followed by a discussion of the related work.

- **Chapter 3: SPLE Management Framework**

Chapter 3 presents the management framework (*K-SPLEMF*) for *SPL* core asset development, and illustrates the framework phases in details.

- **Chapter 4: Case Studies**

In this chapter *SPL* case studies that were used in the thesis are presented.

- **Chapter 5: Result Analysis and Discussion**

This chapter presents results and discussions for the application of our framework phases on the case studies shown in *Chapter 4*.

- **Chapter 6: Conclusions and Future Work**

The thesis is concluded by summarizing the thesis work as well as discusses the strengths and potential limitations of this work. Furthermore, it provides number of suggestions for further work directions on the topic.

CHAPTER 2

Literature Survey

The research done for writing this thesis can be broken down to two major components, Software Product Line (SPL) and Real Option Theory (ROT). There is a wealth of information on both of these topics individually. But it is their common area which is of particular interest to this thesis, and that area remains relatively unexplored.

The goal of this chapter is to provide some background information on the concepts being discussed in this thesis, as well as offer a comprehensive discussion of the related works.

2.1 Background: Definitions and Overview

In this section, an introduction about *SPL* and *ROT* is presented. The key concepts used in this thesis are illustrated briefly to make the reader more familiar with these concepts.

2.1.1 Software Product Lines (SPL)

The *Software Engineering Institute* (*SEI*) defines *SPL* as "*a set of software-intensive systems that share a common, managed set of features satisfying the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way*" [11].

SPL is a family of software applications in a common purpose domain, allocating with a set of common features. Product line variability determines the variety from one application to another [6].

In the early 1990s, software families and product lines concepts came into view. The *Feature-Oriented Domain Analysis* (*FODA*) method description is one of the first contributions in that field [12]. Also, many companies began to deal with this matter more methodically at the same time [13]. This concept (*SPL*) helps companies to develop their products from a core asset instead of starting from the scratch. On the other hand, such as software engineering the development of these assets should utilize the commonality and dial with variability management. Therefore *FODA* approach was become a way to commonality and variability analysis that is used by many researchers in industry and academic [4].

Product line engineering has become an important and widely used approach for efficiently developing portfolios of software products [9]. It is one of the recent and effective reuse approaches [5]. Software product line engineering has gained a broad interest in academic as well as in industry over the past decade [14]. Using *SPL* seeks to maximize reusable variation and eliminate wasteful generic development of components used only once [15]. A number of authors have described the potential benefits that may accrue from using *SPL* techniques in the requirements, architecture, design, coding and testing phases [6, 7, 16].

Variability management is the basic rule in *SPL* that is classified product line components into three types: common, optional and alternative components or features and manage them in the development process. Common features are shared for all products in the family however, alternative is for specific products and optional features could be or not be parts from the products [15].

The reuse of the same assets containing clear variability is the main difference between software product line engineering and other reuse techniques. An example of this is the requirement representations perhaps include a clear description of specific needs which is not applicable to a certain subgroup of products [13].

SPLE is a technique for developing and maintaining products family, taking advantage of their common features and signed variable ones [17]. The commonality and variability exist between the products in a family is the basic structure in the product line [18]. Using *SPLE* in developing product families decreases time and cost, also increases product quality and helps to get customer satisfaction [7, 14].

Frank J. van der Linden et al. in [13] presented four fundamentals concepts at *SPLE* which are: *Variability management, Business-centric, Architecture-centric, and Two-life-cycle approach.*

Figure 2.1; shows that *SPL* follows the tow-life-cycle approach which separates between domain engineering and application engineering. That deal with development for reuse and development with reuse, respectively. The domain engineering addresses handling core-asset development (*which realizes the commonality and variability among family members in the domain*), and identifying common features and reusable variable features. However, the application engineering addresses product development i.e. application requirement analyzing and developing products from common and particular features [8, 13].

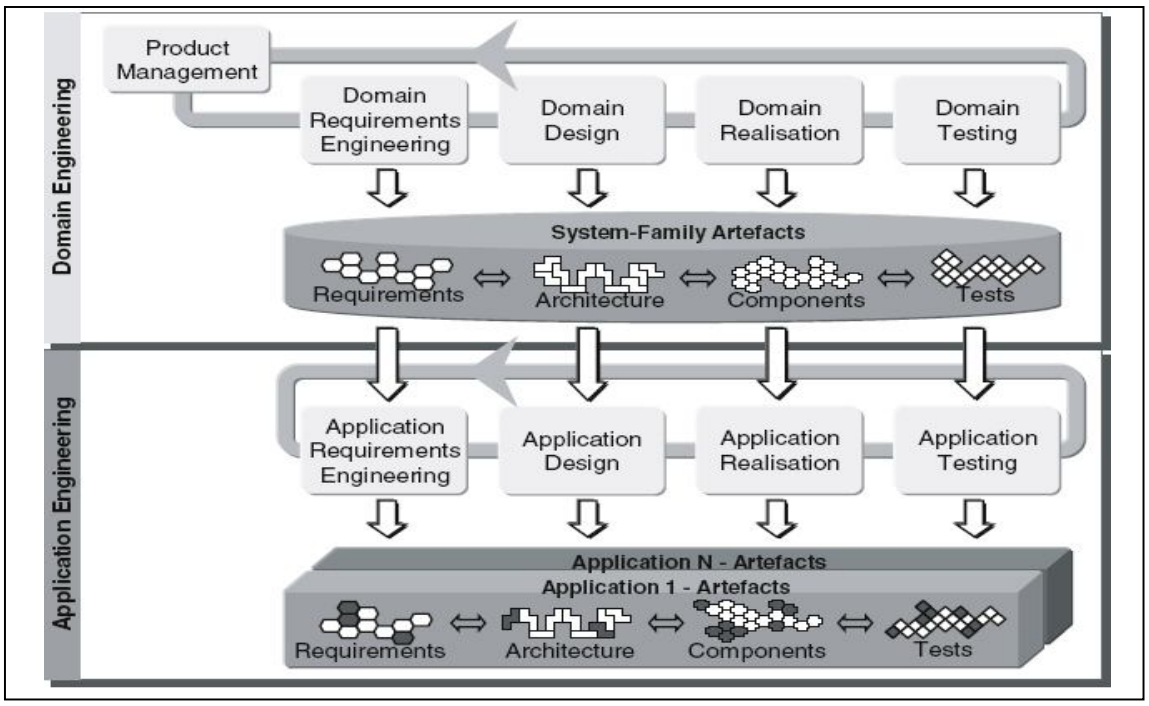

Figure 2.1: The two-life-cycle model of software product line engineering [13]

- **Feature**

Feature "*is a functional requirement; a reusable product line requirement or characteristic.*" Researchers by analyzing and classifying the *SPL* features define three main types of features: *Common, Optional,* and *Alternative* features. The common features are subset of product line features that have to be existed in all product line products. Features that could be needed in some products and not in others are the optional features. Feature is alternative when there is a choice for a feature to be selected from many alternatives for specific products in product line, i.e. one of them could be selected for that product and others should not appear in the same product. Variability in product line is described by the optional and alternative features [16].

The requirement or characteristic which is supplied by one or more members of the product line is a feature in *SPLs* .In general, the features are properties that are used to distinguish between product line members and therefore in the verifying and defining the common and variable features of *SPL*. One of the important things in analyzing product line is feature analyzing. *FODA* ([12]) and other feature-based methods are used for feature analyzing in *SPL* [19].

- **Feature Model:**

Feature modeling is unusually used by authors to describe the management process of variability in *SPLs*. Feature models are used to explain and hierarchically organize common and variable features in *SPL* as a part of the domain analysis method. Product abilities and important properties for user are represented as features [18, 20]. A feature diagram is a graphical representation of a feature model [12]. Analyzing and identifying the features and feature clusters is called feature modeling [16].

Figure 2.2; shows simple feature model example for a *Mobile Phone Software Product Line*.

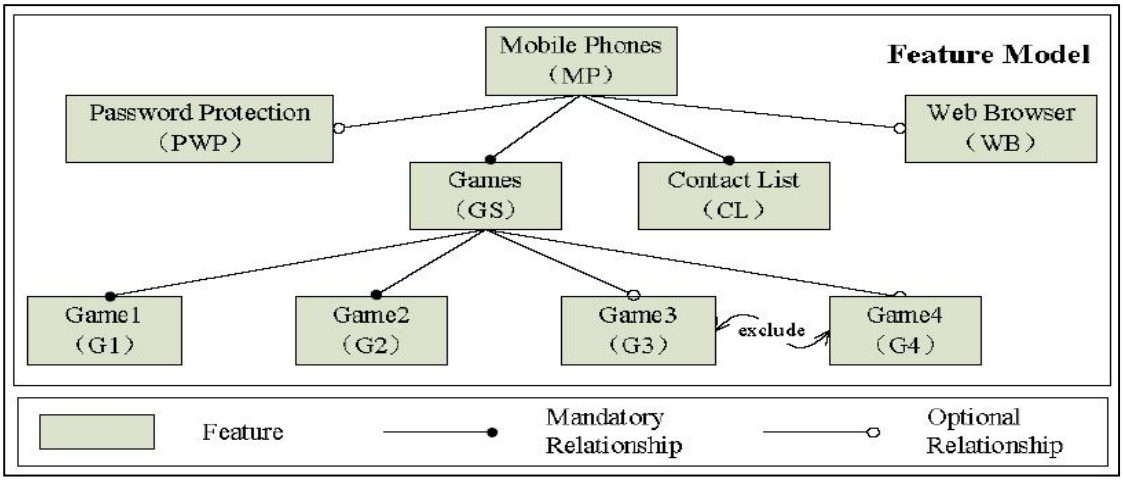

Figure 2.2: A Feature Model of Mobile Phone Software Product Line [21]

2.1.2 Real Option Theory (ROT)

Johnathan Mun in [22] defines real options methodology as "*a systematic approach and integrated solution using financial theory, economic analysis, management science, decision sciences, statistics, and econometric modeling in applying options theory in valuing real physical assets, as opposed to financial assets, in a dynamic and uncertain business environment where business decisions are flexible in the context of strategic capital investment decision making, valuing investment opportunities, and project capital expenditures.*"

The current tools for evaluation and decision-making don't serve the new business realities. The real options are an important aspect to think about how to assess the strategic decision-making. The influence of real option approach is starting the change of economic policy (equation) for many industries [23].

Myers was one of the first researchers who recognize the possibility of applying the techniques of pricing financial options for project evaluation. He recognized that dependent claims on real assets have the option properties, and produced the term real option. Later on, a kind of techniques known as real option analysis, are developed from that idea. These techniques are used to assess the real assets under uncertainty and dynamic decision-making. Formally an option is a flexible future action [24].

Real options theory offers a systematic approach to identify and assess the issues that have an effect on the real options value, which help companies to make a decision under uncertainty [25]. The benefit of real options approach appears on helping managers to plan and manage strategic investments through their available opportunities [23].

As shown in *Figure 2.3*; a higher level of uncertainty leads to a lower asset value in the traditional approaches. However, it can lead to a higher asset value in real options approach if managers recognize and utilize their options to take an action responding to relating events [26].

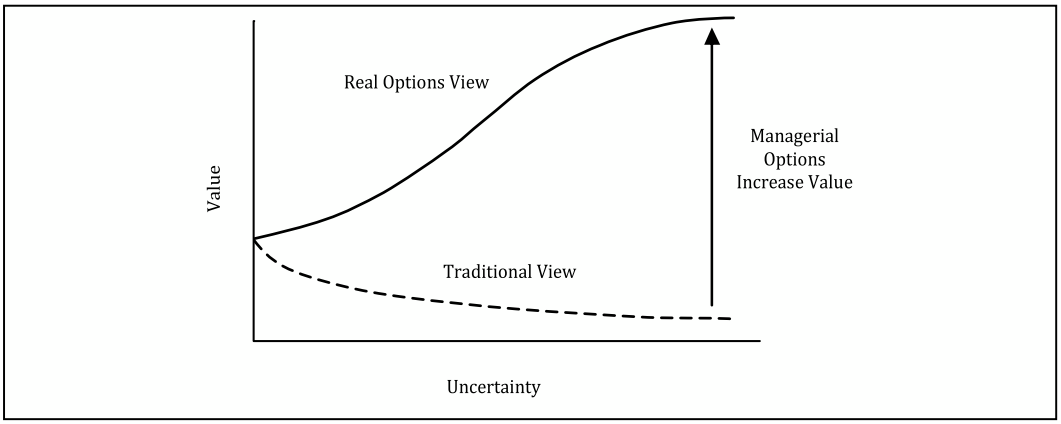

Figure 2.3: Uncertainty Increases Value [26]

- **Option**

An option is a right, but not an obligation. Taking a business decision in the markets is an example of option. In that case the person has the choice to purchase a stock (*Call Option*) or sell that stock (*Put Option*) in the future depending on new or additional information that may increase or decrease the value of stock by fixed price today [27].

- **Options Analysis**

Options analyzing includes set of processes to calculate the value of options, and the system elements that provide flexibility. The result of the analyzing process is a value for a specific option or element of the system [28].

Real options analysis is a technique shows the power of value-generation of flexibility under uncertainty. It is both a method of quantitative estimation and a common analyzing tool to manage risks, by means of basics in both option pricing theory and decision tree analysis [29].

2.2 Literature review and related work

2.2.1 Software Product Line

There are a lot of researches on software product line aspects. Many authors introduce *SPL* concepts, requirement, refactoring, architecture design methods, variability management, features modeling, features dependency analysis, and many other issues in *SPL*. In the following subsections, I'll show briefly *SPL* implementation approaches, features modeling, features binding, marketing product plan, and features dependency analysis.

- **Software Product Line Implementation Approaches**

There are three major activates for *SPL* development. First one is developing the core asset which is called domain engineering; this process includes common assets building and evaluating based on the product feedback and the needs of new markets, etc. Second activity is product development (*application engineering*), in which the individual products are built from the reusable common assets. In addition to develop the products this activity gives feedback to the first process. Management is the third basic activity. It involves technical and organizational management. The technical management considered in requirements controlling and coordination between previous activities [30].

There are two main approaches for *SPL* implementation. These approaches are *proactive* and *reactive* [10]. The proactive approach in *SPL* development is like the waterfall approach in conventional software development. In proactive approach a new *SPL* is analyzed, architected, designed, and implemented to provide all possible needs for a market segment. However, the reactive scenario in *SPL* is like the spiral or extreme

programming. In this approach one or more product line are incrementally developed to provide the current needs. [3, 10, 30, 31].

Applying the proactive approach needs a stable product domain; good experiences in the organization; well predicted for product line requirements in the future; resources and time availability for long time development. However, there are risks for this scenario which cause useless for some products if the business needs or domain identification is changed after creating these products. Therefore, this approach is not used in practice, especially for small and medium size companies [3, 10, 30, 31].

On the other hand, in reactive approach each asset will be used at least once which avoid useless for the produced asset. That is because the developing of reusable assets as needed is based on the rising in the reuse opportunities. Few additional resources will be enough in this approach. There is no need for large investments and no need for well requirement predicting in reactive scenario. Even so, there might be a risk in loss of some business opportunities because the product development is not fast enough. In addition, the absence of product line architecture is another risk that will lead to rebuild of many assets to make them suitable for the products in the future [3, 10, 30, 31].

- SPL Features Modeling

Product lines are briefly identified using feature models techniques which are introduced about two decades ago [12]. Feature models have both a textual notation and a graphical notation with related grammar [32]. In the product line, a feature represent a "behavioral concept" which identify the user needs, it may be a functional or nonfunctional requirement in the systems. The feature modeling aims to analyze the commonality and variability on product line domain [33]. The objective of this analyzing is to develop highly reusable core assets for a product line [20, 34]. Product family is modeled as a hierarchy of features. Features similarities, differences and relationships among them are shown in features model [35]. Researches that addressed SPL variability modeling issues are more than any other researches in *SPLE* fields [36].

Feature modeling organizes and manages a product line's features into a model. These features are organized and classified into four categories: *capability, domain technology, implementation technique, and operating-environment* features [37].

- *Capability Features* are product services, operations, and nonfunctional characteristics.
- *Domain Technology Features* are the implementing ways for services or operations.
- *Implementation Technique Features* represent the techniques for services, operations, and domain functions implementation.
- *Operating-Environment Features* define the environments where the applications are used.

Figure 2.4; shows these categories from a feature model example for *Private Branch Exchange (PBX)* system.

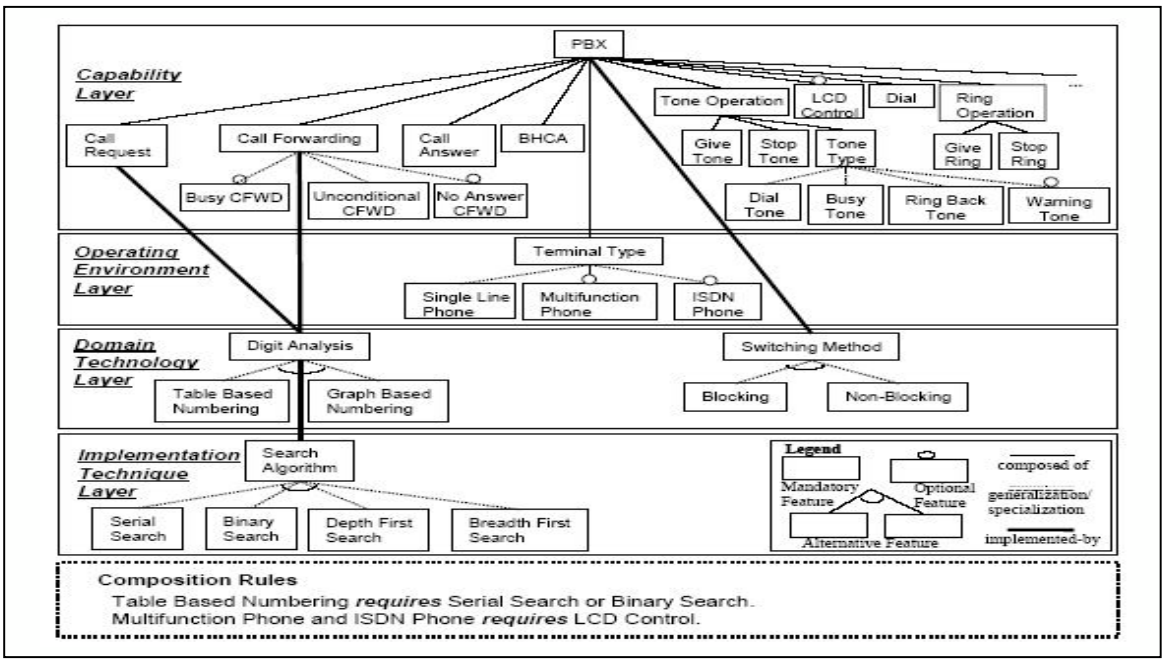

Figure 2.4: A feature model example: PBX product line [20]

There are many approaches for features modeling in *SPL. Feature-Oriented Domain Analysis* (*FODA*) [12] is the first feature modeling approach which many other approaches are derived and or expand it such as *Feature-Oriented Reuse Method* (*FORM*) [38]; *Product Line UML-Based Software Engineering* (*PLUSS*) [39]; *Featured Reuse-Driven Software Engineering Business* (*FeatuRSEB*) [19]; *ConIPF Variability Modeling Framework* (*COVAMOF*) [40]; *probabilistic feature models* (*PFMs*) [41]; (*UbiFEX*) [42]; *Feature-oriented software development* (*FOSD*) [43]; *Feature-based Object Oriented Modeling* (*FOOM*) [33]; and others. *Schobbens et al.* in [44] compared different kinds of feature models and provided unified formal semantics.

Lee et al. [20] illustrated features concepts and feature modeling goals. They introduced practical guidelines for successful *SPLE* based on their experience from using feature modeling in a number of industrial product line projects.

Riebisch [45] introduced feature model as a model that combine between the problem space and the solution space by offering ways for tracing variability [18].

Li and others [21] presented feature map (*and its meta-model*) which is an extending feature modeling for *SPL*, through analyzing the lack of the existing feature models and its description languages. This approach describes feature dependencies perfectly and provides a uniform process of constraint description for feature model and domain application requirement. Also, in a distributed development environment it provides rapid locating for feature resource entities of *SPL*.

Stoiber, Meier, and Glinz [14] provided an approach for *SPL* requirements modeling with aspect-oriented models. They aimed to solve accuracy, efficiency, and consistency problems in *SPL* modeling by: using aspects for variability modeling, manage variability concerns by decision model, and combining relationship semantics with their aspectual to be suitable for the decision model. They got better understandable and maintainable product line requirements model.

- **Feature Binding**

Commonality and variability of a product line are captured in terms of features with a feature model, which is the fundamental input to the feature binding analysis. Feature binding provides essential information for product line asset development. This information includes when and how product features are included in products. There are three main views within feature binding process: the first one is the feature binding unit that means which features have to be included in products and offered to customers; the second view is the feature binding time that is when features are included in products; and the third view is how these features are included in products which called feature binding technique. The information about binding unit and binding time is essential to choose an appropriate binding technique, identify and manage variation points consistency [46].

- **Feature Binding Unit**

Authors define feature binding unit as related set of features based on its relationships (i.e. *composed-of*, *generalization*/*specialization*, and *implemented-by*) and composition rules (i.e., *require* and *mutually exclude*) in a feature model. Features that have to be in the same set for right service operating, should be existed in the same binding unit. The optional or alternative features will be in separate binding units [46].

- **Feature Binding Time**

Binding time is the time in which we choose to include or exclude a feature (or features) in a product line. Features may be included in a product at compile or run time. Binding time takes into account features availability, binding units, and activation rules [46, 47].

Figure 2.5; shows a graphical representation of a feature model with feature binding units for *Home Services Robot* (*HRS*).

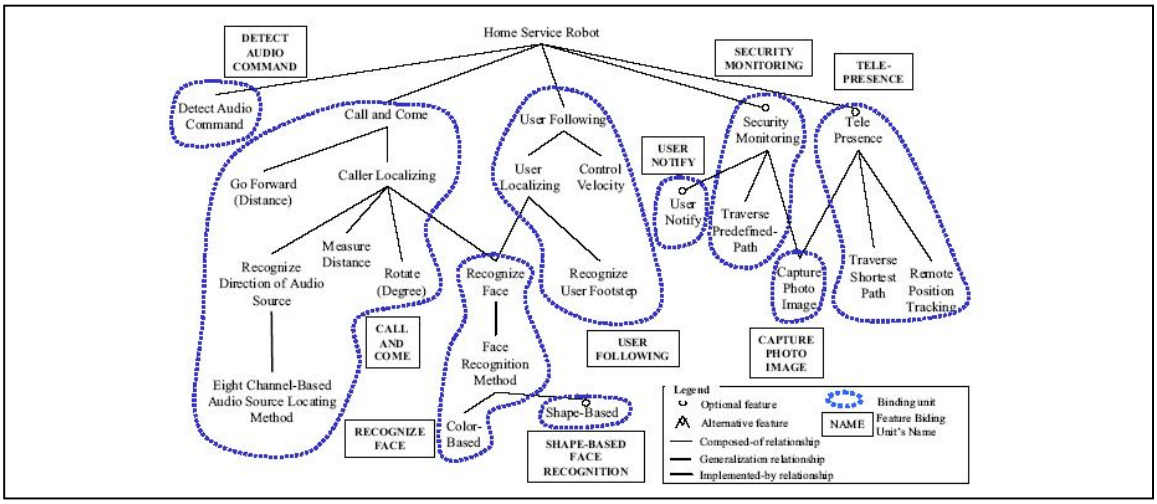

Figure 2.5: A feature model of the HSR product line and its binding unit identification [48]

Lee et al. in their paper [46] introduced a scenario for feature binding analyzing from the three perspectives: what, when, and how features are binding. They applied their approach to a *Home Integration System* (*HIS*) as a case study. They clarified how the analyzing results could be used for developing components in a product line. Feature activation rules and market needs will be taken in account through feature binding units identification and feature binding time determination.

Lee et al. in [49] presented a product line production planning approach based on features. They illustrated how their approach addresses the technical issues for production plan development based on features model and features binding information as a primary key. This approach offers a clear method for the core asset identification and organization. In [34] an approach to reduce difficulty of features grouping into feature binding units of the same binding time is introduced by *Lee et al.* They illustrated how these unites can be used as basics for determining reusable features in product line.

- Marketing and Product Plan (MPP)

Marketing and product plan is introduced as an input key driven from product line asset development. *MPP* identifies what is important for development process not how they will be implemented [50]. It describes the needed information within marketing and business analysis. *MPP* includes a marketing plan and a product plan, that helps analyzing the product line and discovering the reusability in the product line components [49]. The marketing plan includes a market analysis and a marketing strategy. However, the product plan identifies product features and product feature delivery methods [4].

- Marketing Plan

In the marketing plan the market analysis provides information about need assessment, user profile, culture and legal constrains, and business opportunities. On the other hand, the marketing strategy offers information about product delivery methods [51]. *Figure 2.6*; shows the elements of a marketing plan.

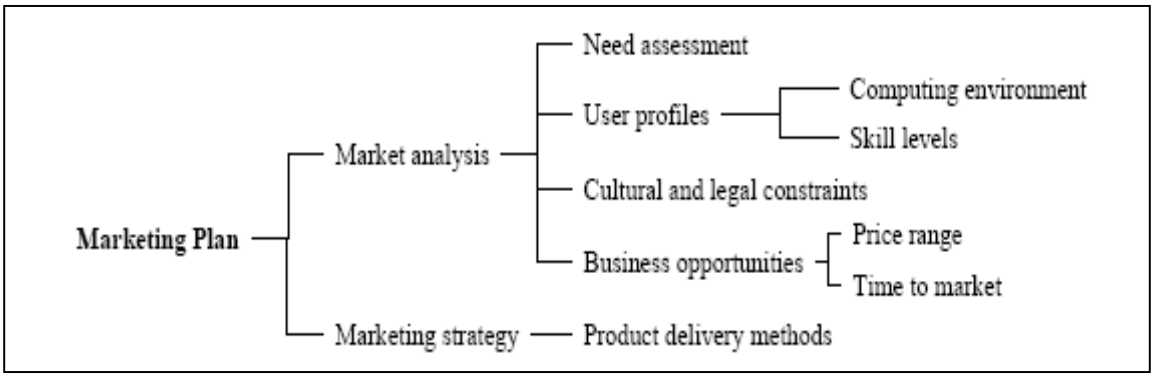

Figure 2.6: Marketing Plan for Product Line Asset Development [51]

- **Product Plan**

After defining the marketing plan, it is necessary to describe features and build a plan to integrate them into the products. Product plan consists of product features and feature delivery methods. Product features provides information about functional and non-functional features while, product feature delivery methods identifies feature coverage, feature binding time, and feature binding techniques [51]. *Figure 2.7*; shows the elements of a product plan.

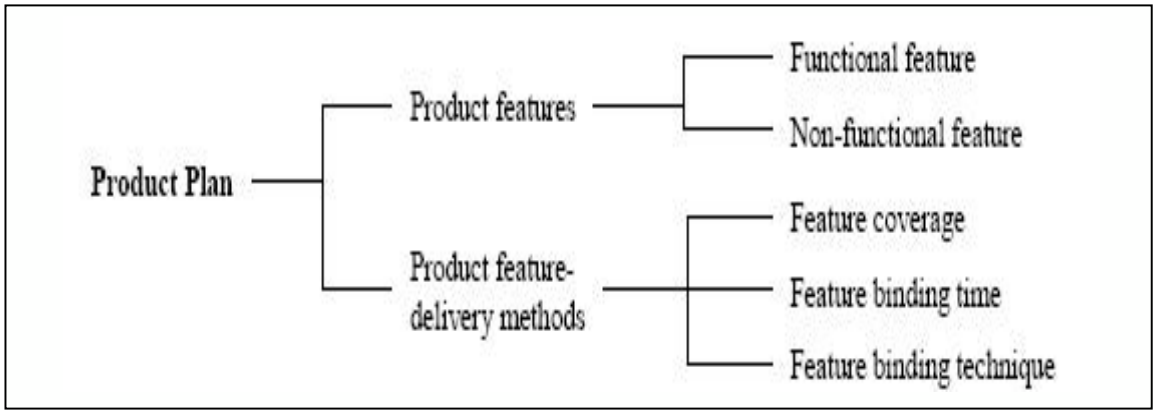

Figure 2.7: Product Plan for Product Line Asset Development [51]

Kang et al. [51] introduced *MPP* as a key driver for product line asset development. In addition, to describing the key elements of *MPP* and how it can be derived, they suggested that both functional and non-functional features should be identified together for *SPL* asset development.

- **Feature Dependency analysis**

SPL features, in general are not independent from each other. There are different dependency types between them [52]. These features dependencies are described by feature dependency model which is an important activity for product line assets development [53]. In the feature modeling the features are organized based on the structural relationships (*i.e., aggregation and generalization*) and the configuration dependencies (*i.e., required and excluded*) [38, 54, 55]. Feature dependency includes inherent hierarchy structure, designing constraints and operating dependencies among features [53]. Usage, Modification, and Activation dependencies between features have important implications on reusability and adaptability of product line assets development [55]. In the following subsections, dependency relations that are related to our work will be illustrated. We show briefly how researchers define these feature dependency relationships and their works in that issue.

- **Operational Dependencies**

  Operational dependency identifies relationships implicitly or explicitly between features during the system operating taking into account that feature (*or features*) is depend on those other features for its correct operating. Operational dependencies classified into two kinds: usage dependency and modification dependency. In *Usage Dependency a* feature may depend on other features for its correct functioning or implementation. However, *Modification Dependency* means that a feature (*a modifier*) may modify the behavior of another feature (*a modifyee*) during its activation [54, 55].

- **Activation Dependencies**

  When the activation of a feature is depend on other feature(s) that is called activation dependency. There are four types of activation dependencies: *Exclusive-Activation*, *Subordinate-Activation*, *Concurrent-Activation*, and *Sequential-Activation* [54, 55].

There are several researches and approaches deal with feature dependencies. Most of them addressed feature dependencies modeling, and some focused on analyzing or management features dependencies. The following are some researches on this aspect.

Fey et al. [56] presented "Modify" relation between features. The feature dependencies are introduced but the effect of these dependencies on product line asset development did not present in their paper. Also, they did not show efficiently how to manage those dependencies in implementation.

S. Ferber, J. Haag, and J. Savolainen, [57] presented an approach to look into feature dependencies and interactions that confine the variants which can be derived from the legacy product line assets. Their approach identified feature model within two views. The first view defines the hierarchical refinement of features in a feature tree similar to common feature modeling methods. The second view shows which type of dependencies and interactions among different features are there. They recognized five kinds of feature dependencies or interactions (*i.e., Intentional Interaction, Resource-Usage Interaction, Environment Induced Interaction, Usage Dependency, and Excluded Dependency*) in the engine control *SPL*. The extended feature model is used to re-engineering a legacy product line.

Lee et al. analyzed feature dependencies which are useful in the design of reusable and adaptable product line components by extending feature modeling. Also, they showed six types of feature dependencies which significantly influences on the design of the product line assets. They emphasized on the solutions to hide variable features from their usage client features. They presented component design guidelines and showed the applicability of their approach via *Elevator Control Software* (*ECS*) product line example. In addition, *lee et al.* introduced guidelines illustrate how feature dependency information can be used for features implementation using object-oriented patterns [55] and using *aspect-oriented programming* (*AOP*) [58]. They provided specific guidelines on how feature dependency analysis and an *AOP* technique (i.e., *AspectJ*) can be combined to support incremental software development [52].

Lee et al. [59] presented an approach to separate features dependencies from feature implementations to compose features in a flexible way and to make product derivation more efficient. They illustrated and evaluated their method using a calculator product line as a case study. However, all features dependencies types did not take into account in their work. They only focused on modification and activation dependencies that have crosscutting effects since their variation may affect feature implementations.

2.2.2 Real Option Theory

Today the business environment is dynamic and managing it should be taken seriously. Strategic flexibility is an important issue there. Opportunities that may produce and losses that may result from unfavorable market developments should be identified and included in the management concepts and techniques. Improving management's abilities to deal with future market situations need the inclusion of the value of possible gains and losses in the strategic analysis. A better strategic approach should take into account the different opportunities. These opportunities will represent as options, rights but not obligations to tack a specific action in the future [60].

Many researches show the application of real options theory to decision making on many fields under uncertainty. The real options theory introduces a new view of thinking about uncertainty that looks to it not just as risks but also as opportunities. This view gives managers at companies the ability to create real options to maintain flexibility responding to the new information. Financial models and option-pricing solution approaches are combined in real options modeling for new and complex problems to identify valuation of uncertainty [25].

In real options theory, there is an economic value for options. This value rises with uncertainty or total risks of core asset. Core assets of real options are the total current value of cash flows expected from the project's capital investment [61].

Many formulas were introduced for computing option pricing in ROT. All of those formulas are derivatives or partially modified from *Black-Scholes* formula. The next subsections show the Black-Scholes and *Chooser Option* formulas that will be used in our framework.

- **The Black-Scholes Option Pricing Formula**

It is a mathematical model used for option pricing on stock which does not pays dividends before the expiry date of the option. The model price is "*fairly close*" to the experimental price as shown in many practical tests [62]. The first publication about this model formula was in 1973 by *Fischer Black* and *Myron Scholes* in their paper, "*The Pricing of Options and Corporate Liabilities.*" Later on, a paper to expand the mathematical understanding of the option pricing model was published by *Robert C. Merton.* He coined the term *Black–Scholes* options pricing model. In 1997 *Nobel Prize* in Economics was awarded to *Merton* and *Scholes* for their work [63].

The *Black-Scholes* formula is a partial differential equation. It shows the option's price over time. "The key idea behind the equation is that one can perfectly hedge the option by buying (*Call Option*) and selling (*Put Option*) the underlying asset in just the right way and consequently "*eliminate risk*". "*This hedge, in turn, implies that there is only one right price for the option, as returned by the Black–Scholes formula.*" [64, 65]

As shown in [62, 64, 65] and by letting c and p denote the price of *Call* and *Put* options, respectively, the Black-Scholes formula is stated as the following:

$$c = S\emptyset(d1) - Xe^{-rT}\emptyset(d2) \quad (1)$$

$$p = Xe^{-rT}\emptyset(-d2) - S\emptyset(-d1) \quad (2)$$

Where

- $d1 = \frac{ln(S/X)+(r+\sigma^2/2)T}{\sigma\sqrt{T}}$
- $d2 = \mathrm{d1} - \sigma\sqrt{\mathrm{T}}$
- *S = Stock price. (The spot price of the underlying asset)*
- *X = Strike price of option.*
- *r = Risk-free interest rate[1] (%).*
- *T = Time to expiration in years.*
- *σ = Volatility of the relative price change of the underlying stock price (%).*
- *∅ = The cumulative normal distribution function[2] (%).*
- $ln(x)$ *is the natural logarithm of* x.

[1] *Risk-free rate is the annual rate, expressed in terms of continuous compounding.In theory; the risk-free rate represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time [66].*

[2] *The cumulative distributions function of the standard normal distribution.*

- **Chooser Option (basic Chooser)**

This is the payoff for a simple chooser option when *t1* < *T2*, or it doesn't work! In addition, it is assumed that the holder has the right to choose either a call or a put with the same strike price at time t1 and with the same expiration date *T2*.

The option value can be computed by the following formula:

$$Option\ Value = S\big(\emptyset(d1) - \emptyset(-d3)\big) - Xe^{-rT_2}\big(\emptyset(d2) - \emptyset(-d4)\big) \quad (3)$$

Where

- $d1 = \frac{ln(S/X)+(r+\sigma^2/2)T_2}{\sigma\sqrt{T_2}}$
- $d2 = d1 - \sigma\sqrt{T_2}$
- $d3 = \frac{ln(S/X)+rT_2+t_1\sigma^2/2}{\sigma\sqrt{t_1}}$
- $d4 = d3 - \sigma\sqrt{t_1}$
- *t1 = time to choose between a call or put (years)*
- *T2 = time to expiration (years)*

- Real Option & IT

Many researchers have shown the use of real options in production investments evolution; and production risks identification, measurement and management [67].

Sullivan et al. [68, 69] showed the use of real option on software engineering. They said that real options analysis could offer a well-view for modularity, structuring projects phases, decisions making, and other dynamic techniques of software design.

In [70] authors showed how the real options can be used to value strategic flexibility in software development including *commercial of-the-shelf* (*COTS*) components. *Erdogmus and Favaro* [29] valued the inherent flexibility in the *Extreme Programming* (*XP*) by using the real options. They saw *XP* as a simple process in good placed for responding to the changes and future opportunities that allow more values to be created than complicated process which tend to freeze the development decisions.

Rocha et al. [67] presented a model to use the real options in *Product Development Process* (*PDP*). Their model allows taking in account the financial issues at each project phase in *PDP*. This model can make the decisions processes in *PDP* more robust.

Wu et al. [71] introduced an active enterprise resources planning (*ERP*) implementation management to deal with *ERP* risks using of real option theory. Real option identifies uncertainties over time; solves uncertainties in changing environments. Flexibility of managers can be improved using this approach. Their approach allows them to take the proper action responding to the changing *ERP* environment; and achieve a more successful *ERP* implementation.

Tao and others [72] presented a technique based on real options for *IT* investments evolution to multiple risks. Their approach helps *IT* managers to build suitable valuation process in *IT* investment decision-making. It helps them to understand *IT* risks and options value interactions clearly. They showed the application of their approach with *ERP* project.

- **Real option and SPL**

Geppert et al. [73] proposed the fundamental idea of *Strategic Product Line Engineering* as a way that handles possible evolutionary paths of a product as a product line. In their work variabilities are considered options that give you the right but not the obligation to develop the evolutionary product in one of several feasible directions. They showed how real option theory could support *Strategic Product Line Engineering* by helping to quantify the value of active management and strategic interaction embedded in different product line investment opportunities. However, they didn't clarify how they used real options and if they use it to select a product member or product features.

2.2.3 Summary of related works

Table 2.1; summarizes the related work presented in this chapter. As table shows there are a number of researches on each topic. However, to the best of our knowledge, no one of them has been addressed the uncertainty problem in the *SPL* core asset development.

Research	Research Work Field							Notices
	Features Modeling	*Features Binding*	*Dependency Analysis*	*MPP*	*ROT & IT*	*ROT & SPL*	*Address Uncertainty Problem in SPL Core Asset Development*	
[14]	√							Provided an *SPL* requirements modeling with aspect-oriented to solve accuracy, efficiency, and consistency problems in *SPL* modeling.
[20]	√							Illustrated features concepts and feature modeling goals.
[45]	√							introduced feature model as a model that combine between the problem space and the solution space by offering ways for tracing variability
[49]	√	√						Addressed the technical issues for production plan development based on features model and features binding information and offered method for the core asset identification and organization.
[21]	√		√					Extended feature modeling for SPL and described feature dependencies perfectly.
[57]	√		√					Recognized five kinds of feature dependencies or interactions. The extending feature model is used to a legacy product line re-engineering.
[46]		√						Introduced a scenario for feature binding analyzing from the three perspectives: what, when, and how features are binding.
[34]		√						Illustrated how binding unites can be used as basics for determining reusable features in product line.
[51]				√				Introduced *MPP* as a key driver for product line asset development.
[52]			√					Combined feature dependency analysis and an *AspectJ* to support incremental software development.
[55]			√					Illustrate how feature dependency information can be used for features implementation using object-oriented patterns.
[56]			√					Presented "*Modify*" relation between features. Managing dependencies in implementation for product line core asset development did not shown.
[58]			√					Illustrate how feature dependency information can be used for features implementation using *AOP*.
[59]			√					Focused on modification and activation dependencies that has crosscutting effects since their variation may affect feature implementations.
[29]					√			Valued the inherent flexibility in the *XP* by using the *ROT*.
[67]					√			Used the real options in *PDP*.
[68, 69]					√			Showed the use of real option on software engineering.
[70]					√			Showed how the real options can be used to value strategic flexibility in software development.
[71]					√			Active *ERP* implementation management to deal with *ERP* risks using of real option theory.
[72]					√			Used *ROT* for *IT* investments evolution to multiple risks.
[73]						√		They showed how real option theory could support *Strategic Product Line Engineering* by helping to quantify the value of active management and strategic interaction embedded in different product line investment opportunities. However, they didn't clarify how they used real options and if they use it to select a product member or product features.
Our work	√	√	√	√		√	√	We analyze feature model, feature dependency, and *MPP* for *SPL*. Also, we use *ROT* to solve the uncertainty problem in *SPL* core asset development process.

Table 2.1: Summary of the related work and our work

2.3 Summary

Chapter Two goes over the body of work that is relevant to our thesis by first covers the basic ideas and general concepts followed by a discussion of the related work; Introduces a background overview and definitions for the main concepts in SPL and ROT; presents the SPL implementation approaches (proactive and reactive), a discussion about feature modelling approaches, features binding unit and time, MPP, and discusses the type of features dependencies relations; Then, illustrates ROT technique, application of ROT in IT and SPL; For each of the previous subjects its concepts are introduced followed by the direction of the previous research in that field.

CHAPTER 3

SPLE Management Framework (*K-SPLEMF*)

In this chapter we present a management framework for SPL development to address the uncertainty challenge associated with software features selection using Real Option Theory.

The management framework consists of these main steps: Identifying features and features attributes by analyzing the Feature Model; classifying SPL features into a number of Features Sets based on features dependencies relations; Calculate the Reuse Opportunity of Features Sets by using Marketing Product Plan (MPP) for the SPL and Features Sets dependencies relations; Finally, we apply ROT to prioritize these Features Sets on the product line core asset development process. These priority results allow SPL developer to make an informed decision to develop (Call Option) a feature (or set of features) in the current SPL core asset development iteration or postpone (Put Option) it to the next development iterations. Figure 3.1; shows K-SPLEMF.

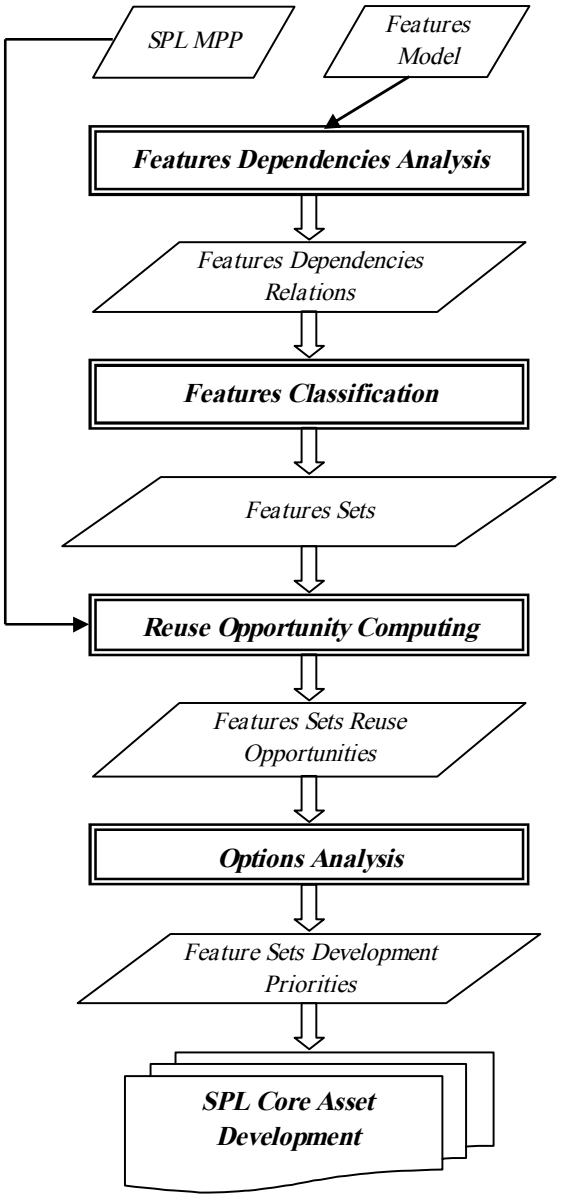

Figure 3.1: SPLE Management Framework (K-SPLEMF)

3.1 SPLE Management Framework Phases

SPLE Management Framework contains four main phases that are: *Features Dependency Analysis*, *Features Classification*, *Reuse Opportunity Computing*, and *Options Analysis*. The description of each phase and its steps are illustrated in details in the following subsection.

3.1.1 Features Dependency Analysis

SPL features in general are not independent from each other. There are different dependencies types between them [58]. *Usage*, *Modification*, and *Activation* dependencies between features have important implications on reusability and adaptability of product line assets development [55].

In this phase to analyze the dependencies relations between *SPL* features we start with *Feature Model Analyzing*. *Feature Model* contains information about features, features attributes and features relations. This step identifies the operational features[3] and their types. Then the dependencies relations are analyzed and each type of relation is identified. *Figure 3.2; shows the K-SPLEMF Features Dependency Analysis* phase.

[3] *The operational features are the functional features and/or services from SPL feature model. These features are the abstracted features that are not generalized into sub-features and these features represent the leaves in the SPL feature model diagram. Leaf features that actually contain code fragments.*

- **Operational Dependency Analysis**

Operational dependency identifies relationships implicitly or explicitly between features during the system operating taking into account that feature (or features) is depend on those other features for its correct operating. Operational dependencies classified into two kinds: usage dependency and modification dependency [54, 55].

Analyzing operational dependency aims to discover the usage and Modification dependencies between *SPL* features.

- **Usage Dependency**

The usage dependency between two features means that *feature B* needs *feature A* for its correct implementation [54, 55]. So that *Feature Usage (FU)* for any feature *A* can be computed as follow:

$$FU(A) = n \quad (4)$$

Where *n* is the total number of features that use feature *A*.

- **Modification Dependency**

Modification dependency means that *feature A* modify the behavior of *feature B* during its activation. We compute *Feature Modification (FMD)* for any feature *A* by:

$$FMD(A) = m \quad (5)$$

Where, *m* is the total number of features that modify by feature *A*.

We can note from *Figure 3.5*; example, that we have 7 features, *F1to F7.Feature Usage* of *F1*and *F2 = 0*. However, *Feature Usage* of *F5* and *F6* equal *3* and *1* respectively. Also, we note that *Modification* dependency for *F4 = 1*.

- **Activation Dependency Analysis**

When the activation of a feature is depend on other feature(s) that is called activation dependency. There are four types of activation dependencies: *Exclusive-Activation, Subordinate-Activation, Concurrent-Activation,* and *Sequential-Activation* [54, 55]. Definitions of the activation dependency types were shown in the two previous references as follow:

a. *Feature B* can be active when *feature A* is active. This is called a *Subordinate-Activation*
b. *Exclusive-Activation* means that *Feature A and feature B cannot be active simultaneously.*
c. *Feature A* and *feature B* must be active concurrently. This type of activation dependency is *Concurrent-Activation.*
d. *Feature B* must be active after *feature A*. This is a *Sequential-Activation.*

We can denote types of feature activation *Feature Subordinate-Activation (FSB), Feature Exclusive-Activation (FEX), Feature Concurrent-Activation (FCN), and Feature Sequential-Activation (FSQ)* for any feature *A* as follow:

$$FSB(A) = vs \quad (6)$$

$$FEX(A) = ve \quad (7)$$

$$FCN(A) = vc \quad (8)$$

$$FSQ(A) = vq \quad (9)$$

Where *vs, ve, vc, and vq* are the total numbers of features that have *Subordinate-Activation, Exclusive-Activation, Concurrent-Activation, and Sequential-Activation* Dependency with feature *A* consecutively.

As shown in *Figure 3.5;* example, the *FSB(F1) = 4, FEX(F1) = 2, FEX(F4)= 3, FSQ(F5)= 1*, and so on for other features in that example.

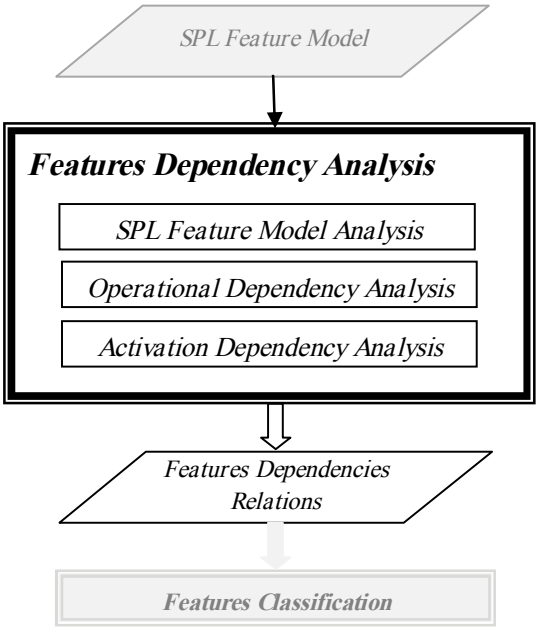

Figure 3.2: K-SPLEMF Features Dependency Analysis Phase

3.1.2 Features Classification

The dependency relations between *SPL* features affect the development process of *SPL* core assets and the whole *SPL's development processes*. For that, and to improve the quality of the *SPL* core assets and to reduce maintenance costs features coupling should be reduced. *SPL* features classification process aims to combine those features that have to be together for correct implementation into the same set. On the other hand, the features that may have negative effect dependency relations have to be in separated sets. Each type of dependency relation will be weighted with a positive or negative value based on the type of relation and its effect. The phase consists of three steps as shown in *Figure 3.3*; *K-SPLEMF Features Classification* phase.

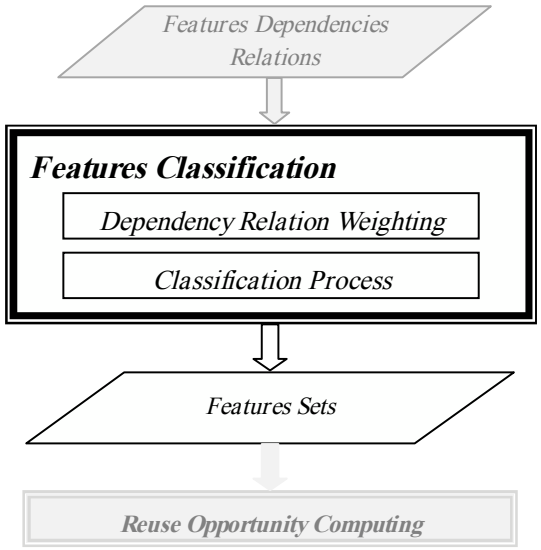

Figure 3.3: K-SPLEMF Feature Classification Phase

- **Dependencies Relations Weighting:**

This step aims to assign and manage the appropriate weight for each features dependency relation. This process helps the classification process for the features. The dependency relations weight procedure consists of four steps. A different weight[4] value will be assigned for each type of dependency relation. Based on the relations number from the same type between a feature and other features this weight will remain positive value or could be converted to negative value. The total value of the weight between two features will be the summation of all relations weights between them.

For any two features the positive weight for dependency relation means more opportunity of these features to be at the same set. However, negative weight means that those two features have to be in separated sets. Figure 3.4; shows *The Dependency Relations Weight Procedure*.

The Dependencies Relations Weight Procedure

I For any two features *A* and *B* the dependency relation weight will be count as follow:

a. Usage = 5.
b. Modification = 2.
c. *Subordinate-Activation* = 3.
d. *Exclusive-Activation* = *-4*.
e. *Concurrent-Activation* = 4.
f. *Sequential-Activation* = *1*.

II If feature *B* has the same dependency relation *(i.e. Used by, Modified by, Sequential-Activation after, and Concurrent-Activation)* with other features in addition to *A*, the dependencies weights between *B* and all other features will be multiply by *(-1)*, for all types of these previous dependencies that have positive weights.

III *Exclusive-Activation* and *Concurrent-Activation* are Correlation dependency relations.

IV Relation weight between two features *A* and *B* will be the summation of weights for all different types of dependency between them.

Figure 3.4: Dependency Relations Weight Procedure

[4] *We have identified these different weights for the dependency relations after conducting several experiments on the systems used in this thesis. We found that those weights give the optimal and logical clustering results. The weights values could be any other numbers with taking into consideration the importance degree and the effect of each type of dependency relations.*

Figure 3.5; shows an example illustrates different type of dependency relations between features and *Table 3.1* shows those features relations then their relations weights are shown in *Table 3.2*.

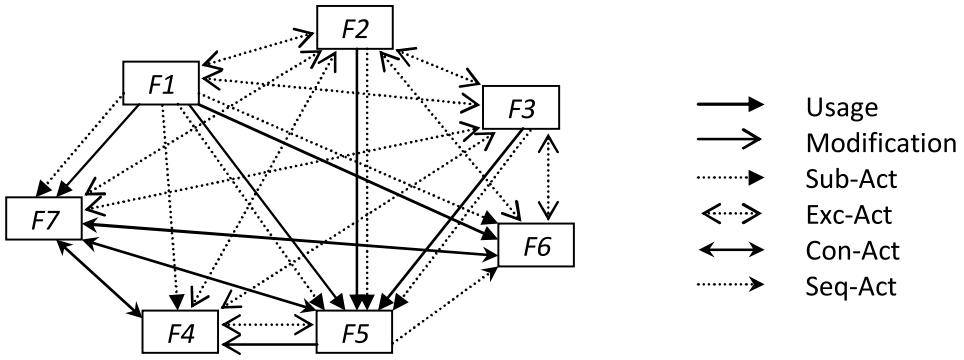

Figure 3.5: Example of dependency relations between features

Feature / Dependency	F1	F2	F3	F4	F5	F6	F7
Used by					F1, F2, F3	F1	F1
Modified by					F4		
Subordinate-Activation to				F1	F1, F2, F3	F1	F1
Exclusive-Activation with	F2, F3	F1, F3, F4, F6, F7	F1, F2, F4, F6, F7	F2, F3, F5	F4	F2, F3	F2, F3
Concurrent-Activation with				F7	F7	F7	F4, F5, F6
Sequential-Activation after						F5	

Table 3.1: Features relations and weights for figure 3.5's example

Relation	Weight		Relation	Weight		Relation	weight
F1,F2	-4		F2,F4	-4		F3,F7	-4
F1,F3	-4		F2,F5	-8		F4,F5	-2
F1,F4	3		F2,F6	-4		F4,F7	-4
F1,F5	-8		F2,F7	-4		F5,F6	1
F1,F6	8		F3,F4	-4		F5,F7	-4
F1,F7	8		F3,F5	-8		F6,F7	-4
F2,F3	-4		F3,F6	-4		--	--

Table 3.2: Features relations and weights for figure 3.5's example

From the above example, we note that *F5* is used and *Subordinate-Activation* by *3* other features (*F1, F2, and F3*) so that, the relations between *F5* and each one of them have weights = *-5 + -3 = -8* for each of them. Although we have *F7* has *Usage* and *Subordinate-Activation* relations with *F1,* and each relation has its weight. So that, the relation between *F7* and *F1* will has the weight = 8. The same thing is for *F6* and *F1* relation. *F5* and *F4* have two types of relations (*Modification* and *Exclusive-Activation*), the *Modification* relation has weight = *2* and the *Exclusive-Activation* has weight = *-4.* The relation weight between *F4* and *F5* will be *2 + (-4) = -2;* and so on for other relations.

- Classification Process

Pajek, which is a network analysis tool, is used for feature classification into sets of features. *Pajek* is a free program for analysis and visualization of large networks. In this work we use version 2.05, for windows 64 bit. For more information about *Pajek* see [74, 75].

Features, features relations, and relations weights will be used as inputs values to the classification tool (*Pajek*). The feature names will represent the network *Nodes* in *Pajek*, and its dependency relation represents the *Edge* between those *Nodes*. The weights values of dependencies relations between them will be the *Weights* for the *Edges* between their corresponding *Nodes* in *Pajek*. The classification process using *Pajek* is implemented under constant conditions for all case studies used in this thesis. *Figure 3.6*; shows these conditions and the classification procedure.

Procedure and Conditions of The Classification Process using *Pajek*

A. *Number of Vertices will be = N which represents the total number of features in the SPL case study under* processing.
B. Create *Random Partition* of *One-Mode* type.
C. The *Dimension of Partition,* which means how many *Nodes* will be in the partitioning process, will be = *N*.
D. *Number of Clusters* will start from *N*.
E. From the *Operations* we implement *Balance* process under these conditions:
    a. *Number of repetitions = 1000.*
    b. *Importance of Neg/Pos error (alpha) = 0.5.*
    c. *Minimum number of vertices in the cluster = 1*, which means there is no empty cluster.
F. The previous steps (*from A to E*) will be repeated *N-1* times. And for each repetition the *Number of Clusters* will be decreased by *1*. The last repetition will be with *Number of Clusters = 1*.
G. For each repetition the clustering process *Error* and *Number of Possible Solutions* will be recorded.
H. The features clustering for each repetition process will be recorded.

Figure 3.6: Procedure and Conditions of the Classification Process using Pajek

The Features Sets (FS) will be identified as the clustering results with the minimum Clustering Error[5] *(and minimum Number of Possible Solutions).*

Table 3.3, shows the *Features Sets* that result from classification process for the previous example shown in *Figure 3.5*, using *Pajek*. Then, *Figure 3.7,* shows theirs sets.

Number of Cluster		*1*	*2*	*3*	*4*	*5*	*6*	*7*
Features	*F1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
	F2	*1*	*2*	*2*	*2*	*2*	*2*	*2*
	F3	*1*	*2*	*2*	*3*	*3*	*3*	*3*
	F4	*1*	*1*	*1*	*1*	*4*	*4*	*4*
	F5	*1*	*1*	*3*	*4*	*5*	*5*	*5*
	F6	*1*	*1*	*1*	*1*	*1*	*1*	*6*
	F7	*1*	*1*	*1*	*1*	*1*	*6*	*7*
Error		*74*	*26*	*13*	*9*	*8*	*12*	*20*
Number of Solutions		*1*	*1*	*1*	*1*	*1*	*2*	*1*

Table 3.3: Result of classification process for example in figure 3.5, using Pajek.

[5] *During the signed graph partitioning (clustering) process if the graph is unbalanced (contained semi-cycles with negative and positive vertices' edges) we will have an error for any partitioning results from the summation of the absolute values of the negative edges within the same cluster (clusters) with the positive edges between different clusters (in the case of undirected edges the error will be counted twice for each negative and positive edges). The clustering process with the lowest error is the closest solution to the optimum clustering of an unbalanced signed graph [76, 77]. (Our case studies are unbalanced signed graphs).*

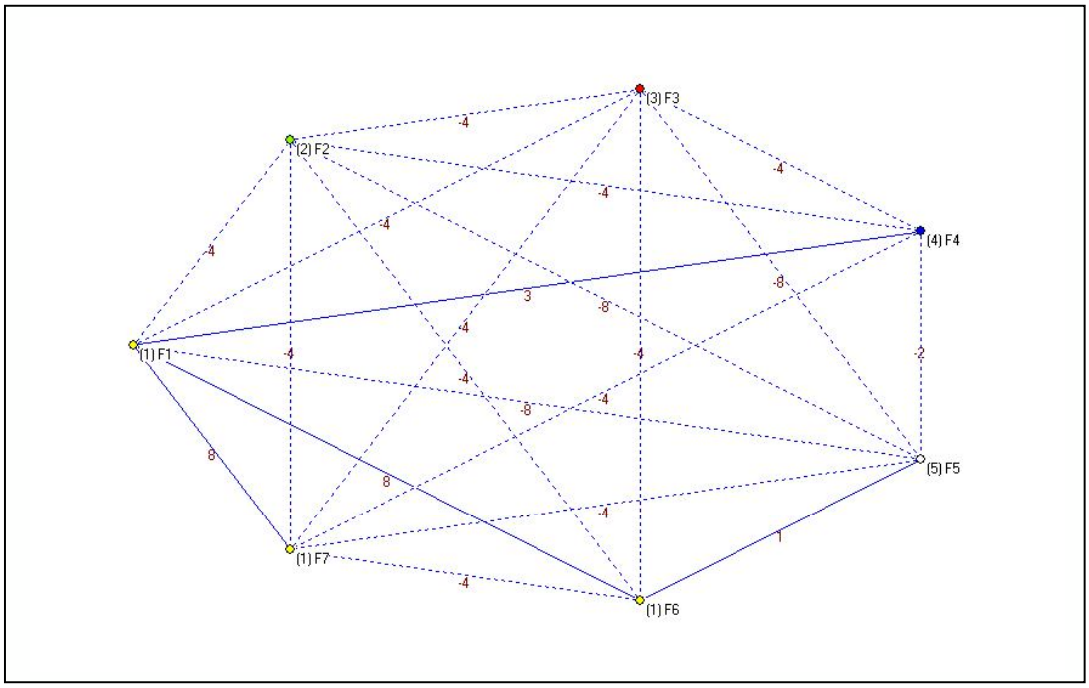

Figure 3.7: Feature Sets for the example in figure 3.5; using Pajek

From the previous figure and table we note that the optimum number of *Features Sets* is *5,* that we have the *minimum Clustering Error = 8* (and *minimum Number of Possible Solutions = 1*).

As shown in *Table 3.3*; and *Figure 3.7*; there are *5 Features Sets (FS1, FS2, FS3, FS4, and FS5). FS1 contains F1, F6, and F7;* each other *Features Sets* contains one feature as shown.

3.1.3 Reuse Opportunity Computing

Features attributes from *SPL Feature Model* analysing and *SPL MPP* analysing in addition to *Features Sets Dependencies* will be identified and each feature attribute will be assessed so that, the *Reuse Opportunity*[6] of each *Features Set* in the *SPL* could be calculated. *Figure 3.8*; shows *K-SPLEMF Reuse Opportunity Computing* phase.

Based on those attributes information there will be three main factors should be calculated for each feature (*or Features Set*). These factors are: *Feature Model* factor (*FMF*); *Marketing Product Plan* Factor (*MPPF*); and *Dependency Factor* (*DF*). The following subsections present these factors and theirs calculating processes.

[6] *The Reuse Opportunity of a feature (or Features Set) is a value which shows the degree of feature (or Features Set) opportunity to be reuse in the variants products of the product family (based on specific factors) regarding to other features (or Features Sets) in a specific scale (e.g. from 1 to 10).*

- **Feature Model Factor (FMF):**

This factor will be calculated based on *FS's* features types as follow:

- *Feature Type (FT)*: this attribute could be one of the three types for each feature:
  - *Common, Optional, and Alternative.*

    Feature Type Weight (FTW) for any feature f will be estimated as the following:

    $$FTW(f) = 1,\ f\ is\ Common\ feature. \quad (10)$$

    $$FTW(f) = 0.5,\ f\ is\ Optional\ feature. \quad (11)$$

    $$FTW(f) = 1 \mid 0,\ f\ is\ Alternative\ feature. \quad (12)$$

    From the above equations we can compute FT for any feature f as follow:

    $$FT(f) = \prod_{i=2}^{m} FTW(f_i) \quad (13)$$

    Where, system *root* is in level *0,* and m is the feature f level in system feature model.

    FMF for a *Features Set X* will be computed as follow:

    $$FSFMF(X) = \frac{\sum_{i=1}^{n} FT(f_i)}{n} \quad (14)$$

    Where n is the number of features in X.

- **MPP Factor (MPPF):**

To compute *MPPF*[7] factor we need to analyze the *SPL MPP* to collect the needed attributes. *SPL Marketing Product Plan* (*MPP)* describes *SPL* marketing plan and *SPL* product plan. In this step we identify *MPP* attributes for *SPL* features from the *SPL MPP*. These attributes are: *Need Assessment, Price Range, Feature Converge,* a*nd Feature Binding Time*. Each attribute represents a sub-factor as follow:

- *Need Assessment (NA)*: this attribute determines the level of need of the feature in a *SPL* for different customers in the targeted markets. Its value will be either *High* or *Low*. *NA* of feature *f* can be estimated as*:*

  $$NA(f) = \frac{x}{M} \quad (15)$$

  Where *x* is the number of customers or markets that will need feature *f*, *M* is the total number of targeted customers or markets.

- *Price Range (PR)*: it is an estimate value of feature price range. It also has a value as *High* or *Low*. *PR* of feature *f* can be estimated as*:*

  $$PR(f) = \frac{x}{M} \quad (16)$$

  Where *x* is the estimated price of feature *f*, *M* is the total estimated price for the whole system.

[7] *For Reuse Opportunity computing if the real estimated values of the MPPF attributes (Need Assessment, Price Range, and Feature Coverage) are not available, their values will be generated syntactically.*

- *Feature Coverage (FC)*: this attribute identifies how much products will need this feature from different *SPL's* products. That means if this feature will be needed for *All* or *Some* of the *SPL*'s products. *FC* of feature f can be estimated as:

$$FC(f) = \frac{x}{M} \quad (17)$$

Where x is the number of products that will need feature f, M is the total number of products on the product line family.

- *Feature Binding Time (FBT)*: this attribute determines when a feature will be included in to the *SPL* product or products i.e. at *Building* time or *Installation* time. *Feature Binding Time Weigh* (*FBTW*) for any feature f will be estimated as the following:

$$FBTW(f) = 1, FBT \text{ of } f \text{ is } Building\ Time. \quad (18)$$

$$FBTW(f) = 0.5, FBT \text{ of } f \text{ is } Installation\ time. \quad (19)$$

Form the above equations *(15) to (19)*, *MPPF* for *Features Set X* can be computed as the following:

$$FSNA(X) = \frac{\sum_{i=1}^{n} NA(f_i)}{n} \quad (20)$$

$$FSPR(X) = \frac{\sum_{i=1}^{n} PR(f_i)}{n} \quad (21)$$

$$FSFC(X) = \frac{\sum_{i=1}^{n} FC(f_i)}{n} \quad (22)$$

$$FSBT(X) = \frac{\sum_{i=1}^{n} FBTW(f_i)}{n} \quad (23)$$

$$FSMPPF(X) = \frac{FSNA(X) + FSPR(X) + FSFC(X) + FSBT(X)}{m} \quad (24)$$

Where, n = number of features f_i in X, m = number of *FSMPPF sub-factors, (here we have m = 4 sub-factors).*

- **Dependency Factors (DF):**

The dependency relations of the *SPL* features are used to compute *DF* for Features Sets. First we need to compute *DF* for each feature in the *Features Set X* then we can calculate *DF* for each *Features Set* with ignoring to the internal dependencies relations between *Features Sets*' features as equations 24 and 25 show.

For each feature *f* we compute *DF* from the previous equations (4) to (9) as follow:

$$DF(f) = \frac{FU(f) + FMD(f) + FSB(f) + FEX(f) + FCN(f) + FSQ\ (f)}{N-1} \quad (25)$$

$$IDF(f) = \frac{y}{N-n} \quad (26)$$

Then the *DF* for *Features Set X* will compute as:

$$FSDF(X) = \frac{\sum_{i=1}^{n} DF(f_i) - IDF(f_i)}{m} \quad (27)$$

Where,

N is number of features in the *SPL* system

y is number of internal dependencies relations for feature f_i with other features in X.

n = number of features f in X.

m = number of *FSDF sub-factors, (here we have m = 6 sub-factors).*

- **Feature Set Reuse Opportunity**

Finally *Features Set Reuse Opportunity (FSRO)* of *Features Set X* will be computed from the previous factors as:

$$FSRO(X) = FSFMF(X) + FSMPPF(X) + FSDF(X) \quad (28)$$

The *Reuse Opportunity* values of *SPL Features Sets* will be the input values to the *Options Analysis* phase.

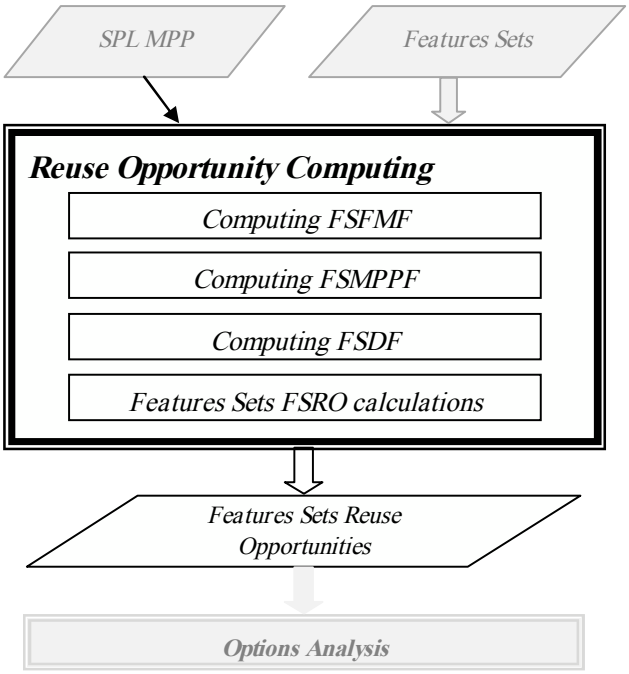

Figure 3.8: K-SPLEMF Reuse Opportunity Computing Phase

3.1.4 Options Analysis

Each *Features Set* will be an option which should be either to develop it in the current development iteration or postpone its development to the coming *SPL* core asset development iterations based on the values of *Call and/or Put* options pricing.

The *ROT* concepts will be used to compute the value of each one of these options. The results will be options valuations that help to put *Features Sets* in the optimum priority for product line core asset development process. The *Black-Schoels* and *Chooser Option* formulas, which are illustrated in *Chapter 2*, are used to compute options pricing by assigning the appropriate parameters from this work instead of the original parameters of the formulas. This replacement is to compute the *Features Sets Reuse Opportunity* valuation. *Figure 3.9*; shows *K-SPLEMF Options Analysis* phase.

- **Reuse Opportunity Valuation**

For the purpose of using the *Black-Scholes* and *Chooser Option* formulas in *K-SPLEMF* the following parameters from our work are assigned to the formulas as follow:

$S = FSRO(A)$, *(Reuse Opportunity* value of a *Features Set A*).
$X = FSRO(System)$, *(Reuse Opportunity* value of the whole *SPL* system).
r = 1% (*constant*)[8].
σ = 25% (*constant*)[9].
$T = N - 1$. (*Available remaining iterations after the development of the Features Set A*)
$T_2 = T$
$t_1 = 1$, *(i.e. each Features Set will be developed in one iteration)*

[8] *Our experiments show that difference between c and p remains positive for all r in]0, 100], and when r = 0 the value of c = p.*

[9] *Also, the experiments show that difference between c and p remains the same for all σ in]0, 100].*

Where, N is number of *Features Sets* in the system, i.e. each *Features Set* will be developed in separate iteration. (*$T=1$ if we will develop the whole system in one iteration*).

So that we can rewrite the formulas as follow:

- *Black-Scholes*:

$$c = S\emptyset(d1) - Xe^{-rT}\emptyset(d2) \quad (29)$$

$$p = Xe^{-rT}\emptyset(-d2) - S\emptyset(-d1) \quad (30)$$

Where

$$d1 = \frac{\ln\left(\frac{S}{X}\right)+(r+\sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d2 = \mathrm{d1} - \sigma\sqrt{\mathrm{T}}$$

- *Chooser Option:*

$$Option\ Value = S\left(\emptyset(d1) - \emptyset(-d3)\right) - Xe^{-rT}\left(\emptyset(d2) - \emptyset(-d4)\right) \quad (31)$$

Where

$$d3 = \frac{ln\left(\frac{S}{X}\right)+rT+\sigma^2/2}{\sigma} \quad (32)$$

$$d4 = d3 - \sigma \quad (33)$$

- **Features Sets Development Priority**

This is the last step in *K-SPLEMF* which shows the results from the previous steps that allow the *SPL* developer to locate the *SPL Features Sets* in the optimum development priority for the *SPL* core assets development.

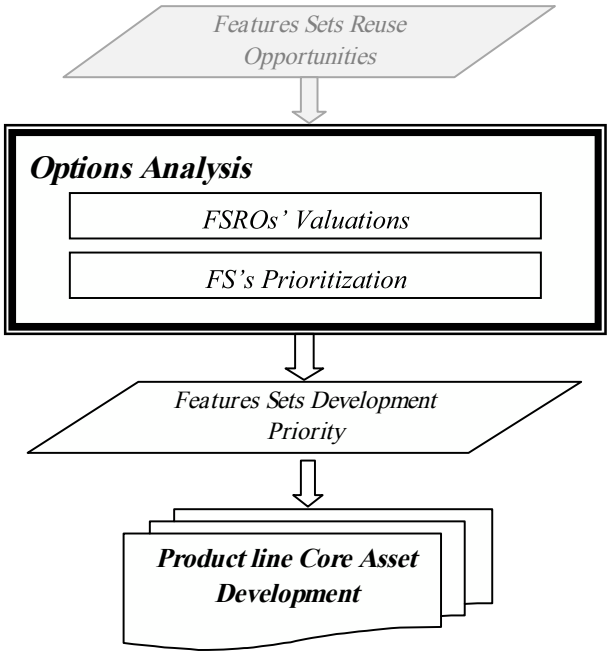

Figure 3.9: K-SPLEMF Options Analysis Phase

3.2 Summary

This chapter illustrates in details the Software Product Line Engineering Management Framework for core asset development (K-SPLEMF). The framework processes start by analyzing SPL Feature Model to identify the operational features. Then, analyzing these features dependencies relations in order to classify them into a number of Features Sets. After that, Features Sets Reuse Opportunities are calculated based on Features Sets dependencies relations and theirs MPP attributes. Finally, the ROT concept is used for pricing these Features Sets Reuse Opportunities in order to prioritize them in SPL core asset development.

CHAPTER 4

Case Studies

This chapter consists of two SPL case studies: Elevator Control System (ECS) and Scientific Calculator System (SCS). We chose these systems since most of the readers will be familiar with their functionality and due theirs simplicity and understandability. Also, to clarify our work regarding to other researchers' works who's used similar examples.

The next few sections will detail the description of these case studies and their unique characteristics. Each section is contains three topics: System and Features Descriptions, Feature Model, and Marketing Product Plan of the SPL case study.

4.1 Elevator Control System (ECS)

In this research work we use *Elevator Control System* (*ECS*) product line as a case study that this system is a popular used at many others researchers work (e.g. [38, 51, 52, 55] and others). It was appeared at these researches with slightly different features number, features names, and feature models. For the purpose of illustration, *ECS* product line is simplified by eliminating non-functional features and some detailed that will not affect the final results (e.g., current floor indication of an elevator, safety-related features, scheduling a group of elevators, etc.)

4.1.1 ECS Features Description

ECS consists of many features. Here we introduce a brief description of the main features. For more details about features descriptions see *Appendix A*.

Main Features of *ECS*:

- Services: this system introduces three services (i.e. *Passenger*, *VIP*, and *Fire Fighter*). Each of them allows the client to use the elevator in slight different way. For example, at the *Passenger* service almost all the elevator tools and operations are available for the client. However, in the *VIP* or *Fire Fighter* services there will be some disabled services (e.g. *Auto Door Open* and *Hall Call Registration* are not available during the *Fire Fighter* service and *VIP* service respectively and so on for some other operations.)
- Door Control: to control the *Door Open*/*Close* operation.
- Move Control: to *Move*/*Stop* the elevator based on the passengers requests.

- Call Handling: is an operation for registering or canceling passenger's call requests from the floors hall and from the elevator car.
- Run Control: this operation control the elevator acceleration and deceleration through number of control operations (*Start Control*, *Stop Control*, *Speed Control*, *Position Control*, *Direction Control*) based on the client requests.
- Environment: Operating environment features include hardware platform related features (*Weight Sensor*, *Position Sensor, Hall Button, and Car Button)* and software related ones that used by client and/or elevator operations.

Figure 4.1; shows *Feature Model* of *ECS* product line. (*This is the refinement feature model.*)

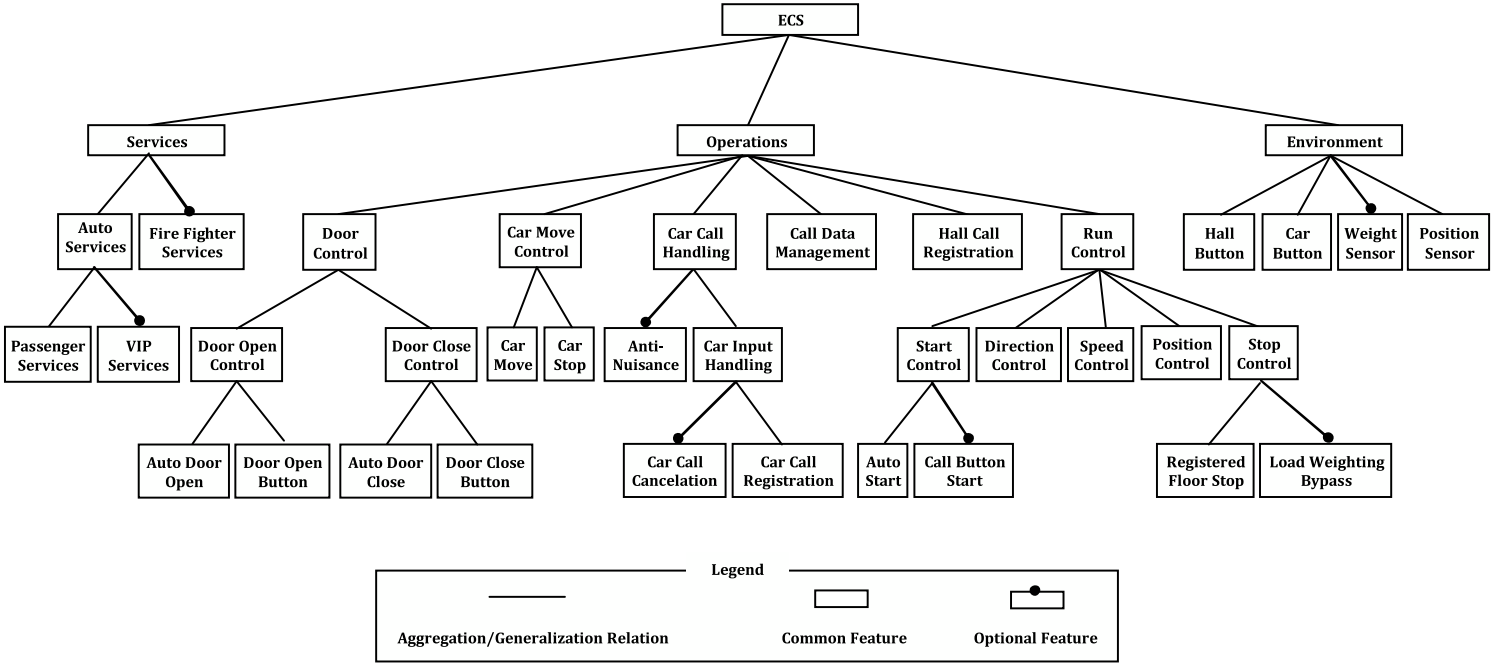

Figure 4.1: Feature Model of ECS Product Line

4.1.2 Marketing Product Plan (MPP) of ECS Product Line

We identify four *MPP* attributes taken from *Marketing Plan* and *Product Plan* of *ECS*. These attribute affects engineering of assets for the *ECS* product line. *ECS* features have different *MPP* attributes based on feature type and/ or *MPP* attribute itself. *Table 4.1*; shows a brief description of *ECS* product line *MPP* attributes. For a detailed *ECS* features *MPP* attributes see *Appendix A*.

MPP Attributes	*ECS* Features Attribute Description
Need Assessment	All common features in *ECS* product line (e.g. *Passenger Services, Move Control*, etc.) will be highly needed for all targeted markets. However, some markets will request the optional features (e.g. *VIP Services, Call Cancelation*, etc) which means highly needs and other markets may not need them that is low need. This Attribute shows the average need of any feature in all targeted markets.
Price Range	Each feature has its prices and this attribute shows feature price range corresponding to product price.
Feature coverage	All common features in *ECS* product line (e.g. *Passenger Services, Move Control*, etc.) will be appeared in all product family members. However, the optional ones (e.g. *VIP Services, Call Cancelation*, etc) will be based on the product members that need them. They could be found in some products and not in the others. This attribute shows for each feature the average need for that feature from all family product members.
Feature Binding Time	All common features will be binding to products at *Building Time*. Optional features will be binding at the *Installation Time* base on the customer needs.

Table 4.1: ECS product line MPP Attributes

4.2 Scientific Calculator System (SCS) Product Line

Scientific Calculator System product line is used in this research work due to its simplicity and understandability. It is also used at many other researchers works (e.g. [54, 59] and others). It was appeared at these researches with small number of features. We use *Microsoft Calculator* (*Windows 7 Calculator*) which we created by refactoring and modifying (by add missing features) those systems feature models were appeared in the previous researches. For the purpose of illustration, *SCS* product line is simplified by combining some features (e.g. the '+', '-', '*', and '/' operations are combined within "*Binary Operations*") and represent them as one feature[10].

4.2.1 SCS Features Description

ECS consists of many features. Here we introduce a brief description of the main features. For more details about features descriptions see *Appendix B*.

Main Features of *SCS*:

- Calculator Type: there are four types of calculator introduced in this system (i.e. *Standard, Scientific, Programmer, and Statistics*). Each of them provides the user with some *Operations/Functions* and *Buttons* (*Binary Operations, e Function, Bin-No Set*, etc.) that others one does not provide them. For example, the *Scientific Calculator Mode* provides the *Basic* and *Scientific Operations*. However, in the *Programming Calculator Mode* provides *Boolean Operations* and some of *Basic Operations* can be used and so on for other calculator mode and operations.

[10] *We do this management process (combining features) to avoid unnecessary and duplicated processing that these combined features have the same dependencies relations with other features (group of features) and there are no dependencies relations between themselves. And we found that these combing processes don't affect the final results of the framework management phases.*

- Calculator Display: this service is used to display the entered numbers, calculator operations, operations' results and error displayed result with an *Expected-Input* and/or operation result *Errors' Notifications* (in the *Calculator Display Box* and *Dialog Boxes*).
- Clearing: this service used clear operations to delete part or all displayed things in the *Calculator Display Box* and *Dialog Boxes*.
- Systems: this service provides user with four number systems (i.e. *Decimal, Hexadecimal, Octane, and Binary*).
- Mode: there are two type of number mode *Size* and *Angle*.
- Notation: numbers in the calculator can be represented in *Basic* or *Scientific Notation*.
- Memory: this service used to store the displayed numbers that can be used latter for some calculator operations. There are three main memory operations: *Store* which contains store (*MS*) number to the memory; add (*M+*) or subtract (*M-*) number to or from the number stored in the memory; *Recall* (*MR*) to display the stored number in the memory; and *Clear* (*MC*) to delete number from the memory.
- History: the calculation *History* service keeps track of all the calculations that calculator performs in a session. This service is available in both the *Standard* and the *Scientific* calculator modes. User can change the values in the calculations history. While he is editing the calculation history, the result of the selected calculation is displayed in the result area from the calculator *Display Box*. Calculation history is kept separately for *Standard* and *Scientific* modes. The history that's displayed depends on the mode that user is using.

- Calculation Operations: it includes *Basic, Scientific, Boolean, Statistics*, and *Extra Operations*. Each of them contains several operations and functions that can be used based on the *Calculator Mode* and *Activated Number System*.
- Numbers Management: it includes *Number Systems* (*Decimal*, *Binary*, etc); *Number Types* (*Decimal, Latter*, etc); *Number Sizes* (*Byte, Word*, etc); and *Number Modes* (*Degrees*, *Radians* and *Grads*).
- Operations management: control and manage the calculator operations behavior and buttons functions.
- Expression Handling: this feature handles the calculation processes and the conversion process between *Number Systems*.
- Environment: Operating environment features include *Calculator Buttons*; *Calculator Display Tools*; and *Calculator Menu*.

Figure 4.2; shows *Feature Model* of *SCS* product line.

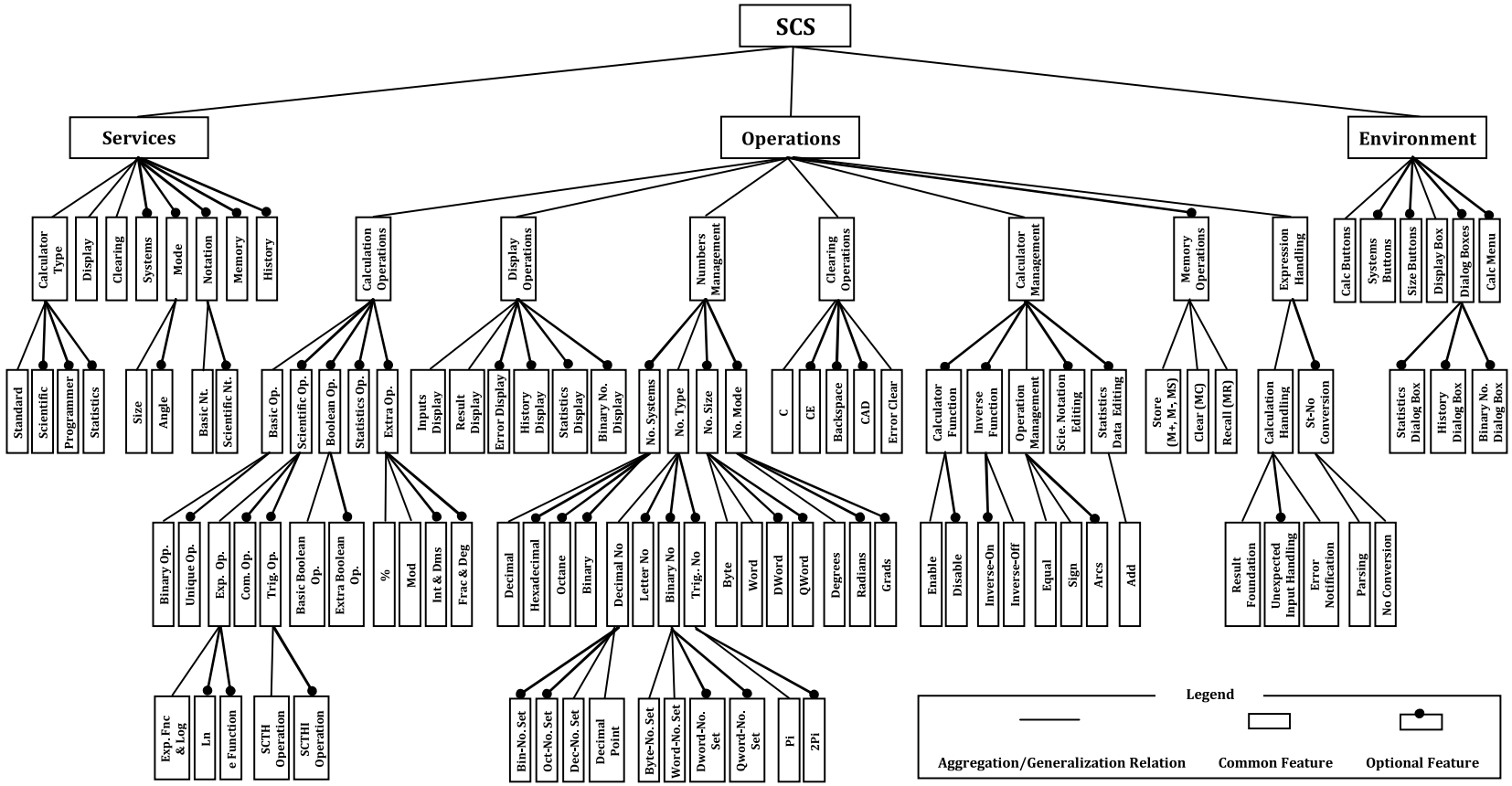

Figure 4.2: Feature Model of SCS Product Line

4.2.2 Marketing Product Plan (MPP) Of SCS Product Line

Table 4.2; shows a brief description of *SCS* product line *MPP* attributes. For a detailed *SCS* features *MPP* attributes see *Appendix B*.

MPP Attributes	*SCS* Features Attribute Description
Need Assessment	All common features in *SCS* product line (e.g. *Standard* calc, *Display Operations*, etc.) will be highly needed for all targeted markets. However, some markets will request the optional features (e.g. *Statistics* calc, *Programmer* calc, *Memory Operations*, etc) which means highly needs and other markets may not need them that is low need. This Attribute shows the average need of any feature in all targeted markets.
Price Range	Each feature has its prices and this attribute shows feature price range corresponding to product price.
Feature coverage	All common features in *SCS* product line (e.g. *Standard* calc, *Display Operations*, etc.) will be appeared in all product family members. However, the optional ones (e.g. *Statistics* calc, *Programmer* calc, *Boolean Operations*, etc) will be based on the product members that need them. They could be found in some products and not in the others. This attribute shows for each feature the average need for that feature from all family product members.
Feature Binding Time	All common features will be binding to products at *Building Time*. Optional features will be binding at the *Installation Time* base on the customer needs.

Table 4.2: SCS product line MPP Attributes

4.3 Summary

In this chapter, we introduce two SPL case studies: Elevator Control System (ECS) and Scientific Calculator System (SCS). We describe each system and its features in details, followed by the system feature model. Finally, we discuss briefly the MPP attributes for each case study.

Each of the case studies has different numbers of features and different number of each type of features. Table 4.3; summarizes these case studies characteristics for Elevator Control System (ECS) and Scientific Calculator System (SCS).

#	Product line Case Study	Characteristics			
		No. of Features	Common Features	Optional Features	Operational Features
1	ECS	35	29	5	25
2	SCS	116	52	64	86

Table 4.3: Summary of Product Line Case Studies Characteristics

CHAPTER 5

Result Discussion and Analysis

In this chapter the results from the different experiments will be discussed and their implications will be analyzed from a variety of perspectives. The results will be analyzed from the viewpoint of each case study where there are number of factors that can be observed, from the results of the framework phases. First, the SPL Dataset generation will be presented. Second the SPL features dependencies relations will be debated. Next the results of classification processes will be presented followed by the results of SPL Features Sets Reuse Assessments will be discussed to see the effect of each Reuse Assessment factor. And finally the SPL Features Sets development priorities results from ROT Options Analysis processes will be illustrated to evaluate the framework performance.

In this chapter, the experiments results of each case study, shown in Chapter 4, are presented in aspirated section. Each section shows the experiments results of the case study for each framework phase shown in Chapter 3. The last section summarizes this chapter results.

5.1 Elevator Control System (ECS)

This section shows the result of application of our framework on the *ECS* product line. The results from each step of the framework phases are presented and discussed.

5.1.1 ECS Features Dependency Analysis

As shown in *Chapter 3*, this phase contains three steps: *Feature Model Analysis, Operational Dependency Analysis,* and *Activation Dependency Analysis*. The results of each step are shown and discussed in the following sub-sections.

- **ECS Feature Model Analysis**

We analyze *ECS* feature model, which is shown in *Chapter 4*, to identify the *Operational Features* and theirs types. As shown in *Table 5.1*; there are *25 Operational Features* in *ECS*, *7* of them are optional features and the rest 18 are common features.

Feature #	Features	*Feature Type*
1	Passenger Service	Common
2	VIP Service	Optional
3	Fire Service	Optional
4	Car Call Cancellation	Optional
5	Car Call Registration	Common
6	Anti-Nuisance	Optional
7	Hall Call Registration	Common
8	Auto Door Open	Common
9	Door Open Button	Common
10	Auto Door Close	Common
11	Door Close Button	Common
12	Auto Start	Common
13	Call Button Start	Optional
14	Speed Control	Common
15	Load Weighing Bypass	Optional
16	Registered Floor Stop	Common
17	Call Data Management	Common
18	Direction Control	Common
19	Position Control	Common
20	Car Move	Common
21	Car Stop	Common
22	Car Button	Common
23	Hall Button	Common
24	Weight Sensor	Optional
25	Position Sensor	Common

Table 5.1: ECS Operational Features and Features Types

- **ECS Features Operational Dependency Analysis**

As discussed in *Chapter 3*, the operational dependencies are *Usage* dependency and *Modification* dependency. The results of *Operational Dependency* analysis of *ECS*[11] features show that *Passenger Service*, *VIP Service* and *Fire Fighter Service* are driving service features as only one of them can be provided at a time. Each one of them has *Usage* dependencies with several features that they depend on those features for their correct operating. *Anti-Nuisance* and *Load Weighting Bypass* depend on *Weight Sensor* for their correct operating (i.e. both of them has *Usage* dependency with *Weight Sensor*).

Car Call Registration and *Registered Floor Stop* have a *Modification* dependency with *Car Call Cancelation* and *Load Weighting Bypass* respectively. *Car Call Cancelation* and *Load Weighting Bypass* modify the behavior of *Car Call Registration* and *Registered Floor Stop* by deleting the registered car calls and ignoring the requested halls stop respectively. Other *Operational Dependencies* between *ECS* features can be seen in *Figure 5.1*; which shows the *Operational Dependencies* analysis results of *ECS* features.

[11] *Part of operational dependency and small part of activation dependencies of ECS were appeared in [52, 54, 55].*

- **ECS Features Activation Dependency Analysis**

In the *ECS* system there will be some features (*a subordinate*) that can be active during the activation of another feature. And they will not be activated if their *superior* is not active. They may be exist a feature that has more than one superior which means it can be activated if any one of them is active (*Car Call Registration* can be active during the activation of either*: Passenger Service, VIP Service* or *Fire Fighter Service*). This type of activation called *Subordinate-Activation*.

As in *ECS* one driving service (*feature*) can be provided at a time which means features *Passenger Service, VIP Service* and *Fire Fighter Service* have *Exclusive-Activation Dependencies* with each other. This means they cannot be active at the same time. The same thing could be said for *Door Open* and *Door Close* features; *Car Move* and *Car Stop* that each pair of them has *Exclusive-Activation* between them respectively.

There are some other features that must be activated concurrently at a time. This type of activation is *Concurrent-Activation*. Each one of *Car Call Registration* and *Car Call Cancelation* has *a Concurrent-Activation* with *Car Button*. Features *Speed Control, Auto Start, Registered Floor Stop,* and *Load Weighting Bypass, have Concurrent-Activation* with *Direction Control* feature.

Car Stop has *Sequential-Activation* with All *Door Control* Features (*Auto Door Open, Door Open Button, Auto Door Close,* and *Door Close Button*), which means those *Door Control* features can be activated after the completion of *Car Stop*.

A complete picture of *ECS* features *Activation Dependencies* can be seen in *Figure 5.2* and *Figure 5.3*. *Table 5.2*; summarizes the dependencies relations between *ECS* features (*we use the letters U, M, S, C, Q, and E to refer to Usage, Modification, Subordinate-Activation, Concurrent-Activation, Sequential-Activation, and Exclusive-Activation respectively*).

Based on *equations* (*4*) to (*9*) in *Chapter 3*, *Table 5.3*; shows the total numbers of dependencies relations for each feature in *ECS* system.

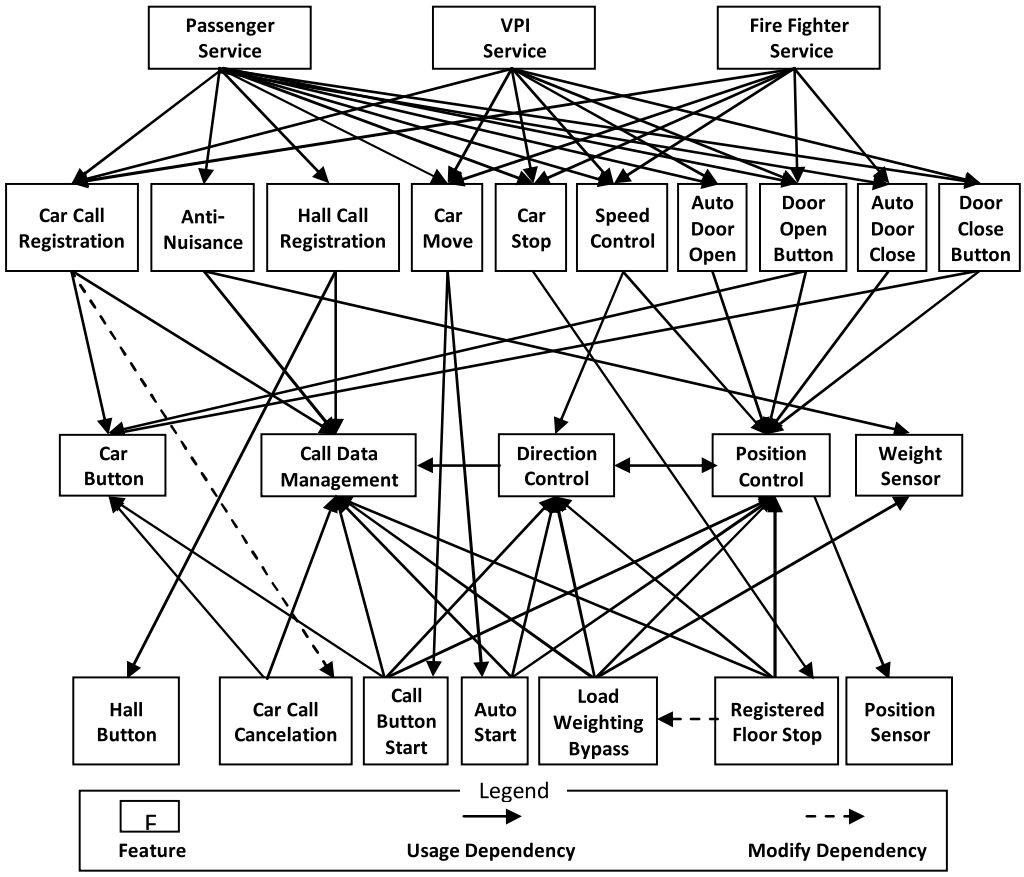

Figure 5.1: Features Operational Dependency in the ECS product line

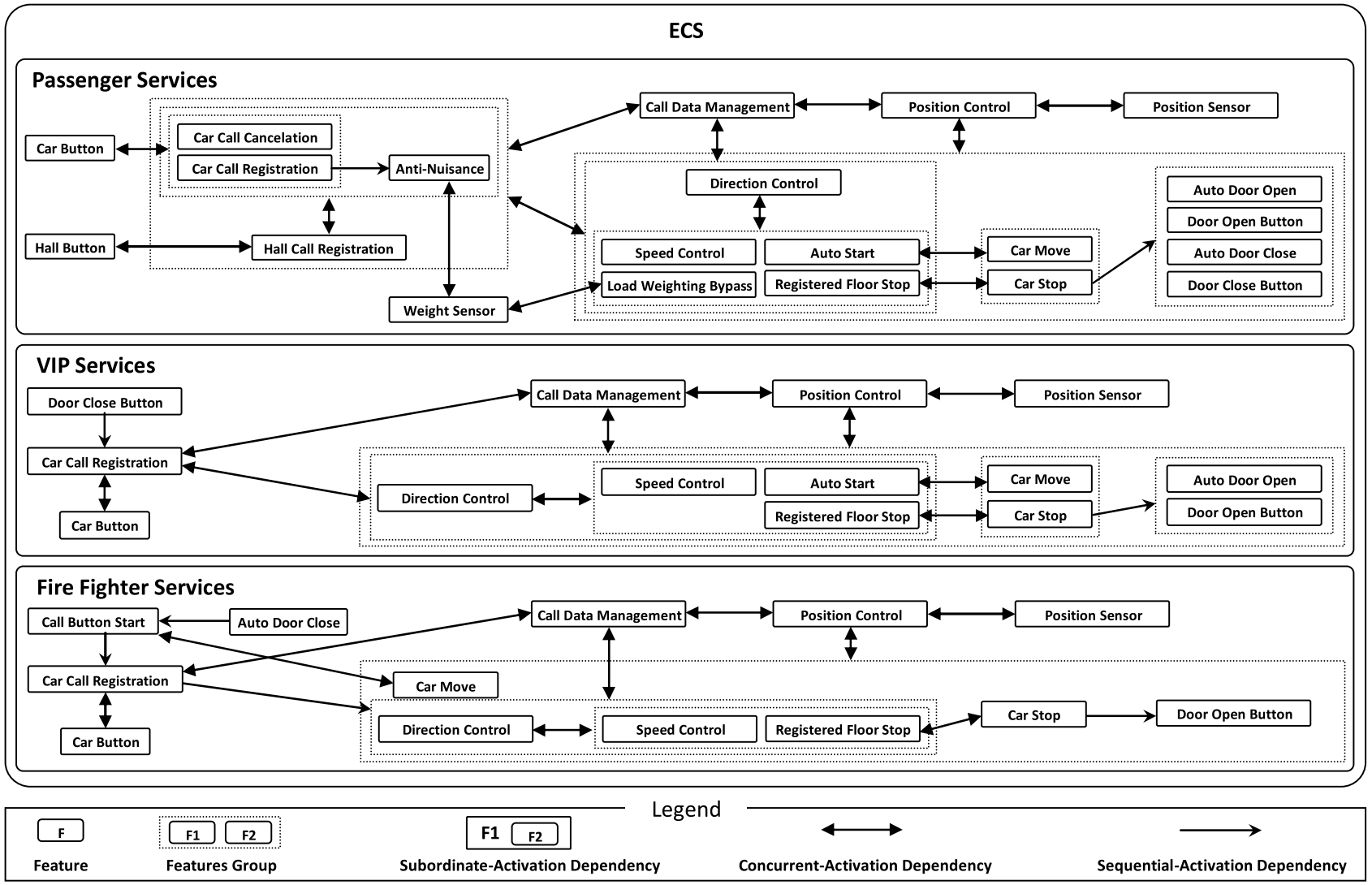

Figure 5.2: Features Activation Dependency in the ECS product line

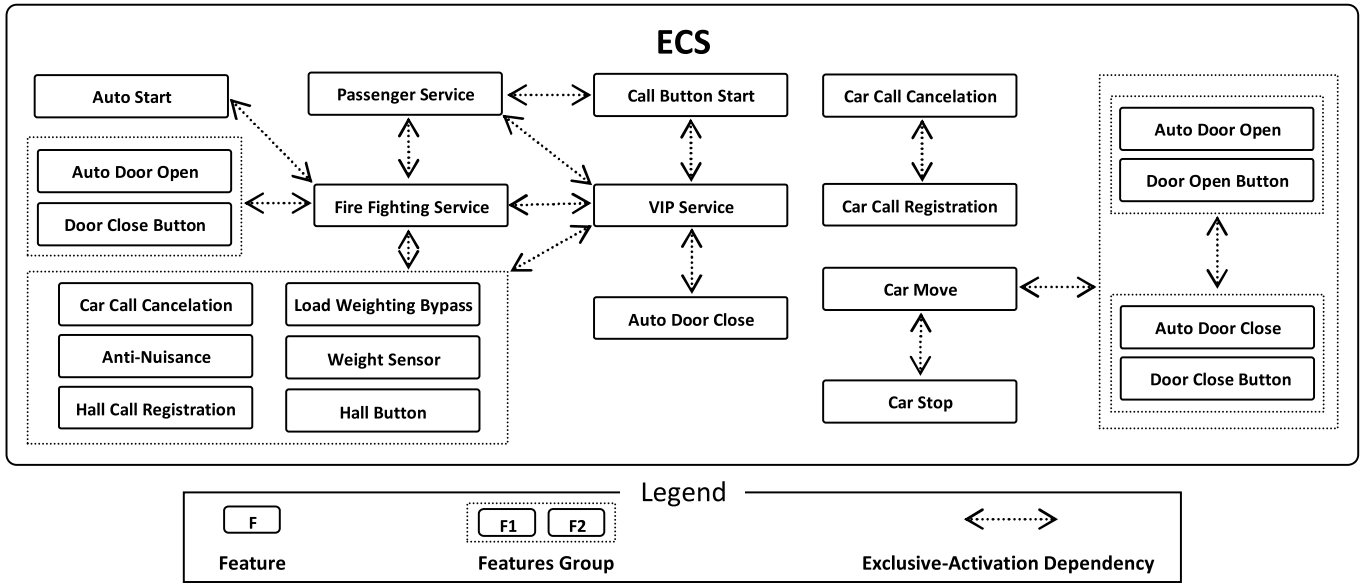

Figure 5.3: Exclusive- Activation Dependency in the ECS product line

	Feature	1 Passenger Service	2 VIP Service	3 Fire Service	4 Car Call Cancellation	5 Car Call Registration	6 Anti-Nuisance	7 Hall Call Registration	8 Auto Door Open	9 Door Open Button	10 Auto Door Close	11 Door Close Button	12 Auto Start	13 Call Button Start	14 Speed Control	15 Load Weighing Bypass	16 Registered Floor Stop	17 Call Data Management	18 Direction Control	19 Position Control	20 Car Move	21 Car Stop	22 Car Button	23 Hall Button	24 Weight Sensor	25 Position Sensor
1	Passenger Service	-	E	E	S	S	S	S	S	S	S	S	S	E	S	S	S	S	S	S	S	S	S	S	S	S
2	VIP Service	E	-	E	E	S	E	E	S	S	E	S	S	E	S	E	S	S	S	S	S	S	S	E	E	S
3	Fire Service	E	E	-	E	S	E	E	E	S	S	E	E	S	S	E	S	S	S	S	S	S	S	E	E	S
4	Car Call Cancellation		E	E	-	ME		C					C		C	C	C	C	C				C			
5	Car Call Registration	U	U	U	E	-	Q	C					C		CQ	C	CQ	C	CQ				C			
6	Anti-Nuisance	U	E	E			-	C					C		C	C	C	C	C						C	
7	Hall Call Registration	U	E	E	C	C	C	-					C		C	C	C	C	C					C		
8	Auto Door Open	U	U	E					-		E	E								C	E					
9	Door Open Button	U	U	U						-	E	E								C	E					
10	Auto Door Close	U	E	U					E	E	-			Q						C	E					
11	Door Close Button	U	U	E		Q			E	E		-								C	E					
12	Auto Start			E	C	C	C	C					-					C	C	C	UC					
13	Call Button Start	E	E			Q								-							UC					
14	Speed Control	U	U	U	C	C	C	C							-			C	C	C						
15	Load Weighing Bypass		E	E	C	C	C	C								-	M	C	C	C					C	
16	Registered Floor Stop				C	C	C	C									-	C	C	C		UC				
17	Call Data Management				UC	UC	UC	UC					UC	U	C	UC	UC	-	UC	C						
18	Direction Control				C	C	C	C					UC	U	UC	UC	UC	C	-	UC						
19	Position Control								UC	UC	UC	UC	UC	U	UC	UC	UC	C	UC	-	C	C				C
20	Car Move	U	U	U					E	E	E	E	C	C						C	-	E				
21	Car Stop	U	U	U					Q	Q	Q	Q					C			C	E	-				
22	Car Button				UC	UC				U		U		U									-			
23	Hall Button		E	E				UC																-		
24	Weight Sensor		E	E			UC									UC									-	
25	Position Sensor																			UC						-

Table 5.2: ECS Features Operational and Activation Dependencies

Feature #	Features	*Dependency Factors*						
		Usage	Modification	Subordinate-Activation	Exclusive-Activation	Concurrent-Activation	Sequential-Activation	Total
1	Passenger Service	0	0	21	3	0	0	24
2	VIP Service	0	0	14	10	0	0	24
3	Fire Service	0	0	13	11	0	0	24
4	Car Call Cancellation	0	1	0	3	8	0	12
5	Car Call Registration	3	0	0	1	8	4	16
6	Anti-Nuisance	1	0	0	2	8	0	11
7	Hall Call Registration	1	0	0	2	10	0	12
8	Auto Door Open	2	0	0	4	1	0	7
9	Door Open Button	3	0	0	3	1	0	7
10	Auto Door Close	2	0	0	4	1	1	8
11	Door Close Button	2	0	0	4	1	1	8
12	Auto Start	1	0	0	1	8	0	10
13	Call Button Start	1	0	0	2	1	1	5
14	Speed Control	3	0	0	0	7	0	10
15	Load Weighing Bypass	0	1	0	2	8	0	11
16	Registered Floor Stop	1	0	0	0	8	0	9
17	Call Data Management	9	0	0	0	10	0	19
18	Direction Control	6	0	0	0	10	0	16
19	Position Control	10	0	0	0	13	0	23
20	Car Move	3	0	0	5	3	0	11
21	Car Stop	3	0	0	1	2	4	10
22	Car Button	5	0	0	0	2	0	7
23	Hall Button	1	0	0	2	1	0	4
24	Weight Sensor	2	0	0	2	2	0	6
25	Position Sensor	1	0	0	0	1	0	2

Table 5.3: ECS Features Dependencies Values

5.1.2 ECS Features Classification

This section presents the classification results of *ECS* features. It contains two sub-sections: *ECS Dependencies Relations Weighting* and *ECS Features Classification Process*. Each sub-section will present and discuss the *classification* phase step results. The outcome of this section will be *ECS Features Sets*.

- **ECS dependencies Relations Weighting**

  Before starting weighting process we have to adjust the information shown in *Table 5.2*. This adjustment process is done in two steps: *Transferring*[12] and *Removing*[13]. For more details about the adjustment process see *Appendix A*. *Table 5.4*; shows the results of *Adjustment Process*. We use these results to implement the weighting process.

  As presented in *Chapter 3*, the weighting procedure is applied for each *ECS* features relation. Form *Table 5.4*; we notice that Car Call Registration feature is used by three features (*Passenger Service, VIP Service,* and *Fire Fighter Service*) also, these three features are *superior* features for *Car Call Registration* (*they have Subordinate-Activation relations with it*). The weight for *Usage* relation = *5*; and weight *Subordinate-Activation relations* = *3*; so that, based on that procedure the relations between *Car Call Registration* and each one of the three features will be multiplied

[12] *During the Classification Process – Adjustment Transferring, for any two group of features (A's, B's) and feature's dependency relation X, from each A to other feature/features B's, we need to calculate number of features B's that affected each one of A's by X, as effectors for each one of A's. However, when we compute the dependency factors we calculate the number of features A's that depends on each one of B's in term of X as dependency factor for each one of B's.*

[13] *In the Classification process – Adjustment Removing, we need to calculate number of relations (each two features related by one relation, i.e. we count the relation from one side). However, during the computation of dependency factor we count the same relation as two relations (i.e. it counted from both sides).*

by *-1* for *Usage* and *Subordinate-Activation*; then the relations weight between *Car Call Registration* and (*Passenger Service, VIP Service,* and *Fire Fighter Service*) will be *-5 + (-3) = -8* for each relation.

The results of applying weighting process for all *ECS* features relations are shown in *Table 5.5;* and *Table 5.6*; shows the final features relations weights after calculating the relations weights between each two features as discussed in *step IV* in the *Weighting Procedure*.

- **ECS Features Classification Process**

After we get the features relations weights we transform these data to a text file (*the content of the text file can be seen in Appendix A*). Then, we used *Pajek* tool as discussed in *Chapter 3*, to classify *ECS* features into number of Features Sets. *Table 5.7*; shows the clustering results of *ECS* features using *Pajek*.

As shown in *Table 5.7*; we start the clustering process with *Number of Clusters = 25*, which means each feature will be in a separated cluster, and repeat the *Classification Process 25* times until *Number of Clusters = 1, which means* all *ECS* features be in one cluster.

As discussed in *Chapter 3*, we select the classification results based on the *Minimum Clustering Error* (and *Minimum Number of Possible Solutions*). Form the results shown in *Table 5.7*; we notice that we have *8* clustering results share the same value of *Minimum Clustering Error = 18*, and form these results the one which has the *Minimum Number of Possible Solutions = 2*, is the result clustering when number of clusters = *15*. From this result we identify the *ECS Features Sets* as shown in

Table 5.8; in which we notice that the first Features Sets contains *4* features (*Passenger Service, Anti-Nuisance, Hall Call Registration, and Hall Button*). More details about the *Classification Process* results from *Pajek* are presented in *Appendix A*.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Number of features that is					
	Feature	Passenger Service	VIP Service	Fire Service	Car Call Cancellation	Car Call Registration	Anti-Nuisance	Hall Call Registration	Auto Door Open	Door Open Button	Auto Door Close	Door Close Button	Auto Start	Call Button Start	Speed Control	Load Weighing Bypass	Registered Floor Stop	Call Data Management	Direction Control	Position Control	Car Move	Car Stop	Car Button	Hall Button	Weight Sensor	Position Sensor	Use	Modify	Subordinate-activate (superior)	exclude-activate	concurrent-activate	sequential-activate
1	Passenger Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	3	0	0
2	VIP Service	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	10	0	0
3	Fire Service	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	11	0	0
4	Car Call Cancellation	S	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	3	8	0
5	Car Call Registration	US	US	US	ME	-	-	-	-	-	-	Q	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	3	1	3	1	8	2
6	Anti-Nuisance	US	E	E	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	2	8	1
7	Hall Call Registration	US	E	E	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	2	10	0
8	Auto Door Open	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	2	0	2	4	1	1
9	Door Open Button	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	3	0	3	3	1	1
10	Auto Door Close	US	E	US	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	2	0	2	4	1	1
11	Door Close Button	US	US	E	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	2	0	2	4	1	1
12	Auto Start	S	S	E	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	1	0	2	1	8	0
13	Call Button Start	E	E	S	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	1	0	1	2	1	1
14	Speed Control	US	US	US	C	CQ	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	3	0	7	1
15	Load Weighing Bypass	S	E	E	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	2	8	0
16	Registered Floor Stop	S	S	S	C	CQ	C	C	-	-	-	-	-	-	-	M	-	-	-	-	-	U	-	-	-	-	1	1	3	0	8	1
17	Call Data Management	S	S	S	UC	UC	UC	UC	-	-	-	-	UC	U	C	UC	UC	-	U	-	-	-	-	-	-	-	9	0	3	0	10	0
18	Direction Control	S	S	S	C	CQ	C	C	-	-	-	-	UC	U	UC	UC	UC	C	-	U	-	-	-	-	-	-	6	0	3	0	10	1
19	Position Control	S	S	S	-	-	-	-	UC	UC	UC	UC	UC	U	UC	UC	UC	C	UC	-	-	-	-	-	-	-	10	0	3	0	13	0
20	Car Move	US	US	US	-	-	-	-	E	E	E	E	C	C	-	-	-	-	-	C	-	-	-	-	-	-	3	0	3	5	3	0
21	Car Stop	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	E	-	-	-	-	-	3	0	3	1	2	0
22	Car Button	S	S	S	UC	UC	-	-	-	U	-	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	5	0	3	0	2	0
23	Hall Button	S	E	E	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	2	1	0
24	Weight Sensor	S	E	E	-	-	UC	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	2	0	1	2	2	0
25	Position Sensor	S	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	1	0	3	0	1	0

Table 5.4: ECS Features Dependencies after Adjustment Process

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Feature	Passenger Service	VIP Service	Fire Service	Car Call Cancellation	Car Call Registration	Anti-Nuisance	Hall Call Registration	Auto Door Open	Door Open Button	Auto Door Close	Door Close Button	Auto Start	Call Button Start	Speed Control	Load Weighing Bypass	Registered Floor Stop	Call Data Management	Direction Control	Position Control	Car Move	Car Stop	Car Button	Hall Button	Weight Sensor	Position Sensor
1	Passenger Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	VIP Service	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Fire Service	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Car Call Cancellation	3	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Car Call Registration	-8	-8	-8	-2	-	-	-	-	-	-	-1	-	-1	-	-	-	-	-	-	-	-	-	-	-	-
6	Anti-Nuisance	8	-4	-4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Hall Call Registration	8	-4	-4	-4	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Auto Door Open	-8	-8	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
9	Door Open Button	-8	-8	-8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
10	Auto Door Close	-8	-4	-8	-	-	-	-	-4	-4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
11	Door Close Button	-8	-8	-4	-	-	-	-	-4	-4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
12	Auto Start	-3	-3	-4	-4	-4	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
13	Call Button Start	-4	-4	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
14	Speed Control	-8	-8	-8	-4	-3	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Load Weighing Bypass	3	-4	-4	-4	-4	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Registered Floor Stop	-3	-3	-3	-4	-3	-4	-4	-	-	-	-	-	-	-	2	-	-	-	-	-	5	-	-	-	-
17	Call Data Management	-3	-3	-3	-9	-9	-9	-9	-	-	-	-	-9	-5	-4	-9	-9	-	-5	-	-	-	-	-	-	-
18	Direction Control	-3	-3	-3	-4	-3	-4	-4	-	-	-	-	-9	-5	-9	-9	-9	-4	-	-5	-	-	-	-	-	-
19	Position Control	-3	-3	-3	-	-	-	-	-9	-9	-9	-9	-9	-5	-9	-9	-9	-4	-9	-	-	-	-	-	-	-
20	Car Move	-8	-8	-8	-	-	-	-	-4	-4	-4	-4	-4	-4	-	-	-	-	-	-4	-	-	-	-	-	-
21	Car Stop	-8	-8	-8	-	-	-	-	-	-	-	-	-	-	-	-	-4	-	-	-4	-4	-	-	-	-	-
22	Car Button	-3	-3	-3	-9	-9	-	-	-	-5	-	-5	-	-5	-	-	-	-	-	-	-	-	-	-	-	-
23	Hall Button	3	-4	-4	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Weight Sensor	3	-4	-4	-	-	-9	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-	-	-	-
25	Position Sensor	-3	-3	-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-

Table 5.5: ECS Features Relations Weights

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Feature	Passenger Service	VIP Service	Fire Service	Car Call Cancellation	Car Call Registration	Anti-Nuisance	Hall Call Registration	Auto Door Open	Door Open Button	Auto Door Close	Door Close Button	Auto Start	Call Button Start	Speed Control	Load Weighing Bypass	Registered Floor Stop	Call Data Management	Direction Control	Position Control	Car Move	Car Stop	Car Button	Hall Button	Weight Sensor	Position Sensor
1	Passenger Service	-	-4	-4	3	-8	8	8	-8	-8	-8	-8	-3	-4	-8	3	-3	-3	-3	-3	-8	-8	-3	3	3	-3
2	VIP Service	-	-	-4	-4	-8	-4	-4	-8	-8	-4	-8	-3	-4	-8	-4	-3	-3	-3	-3	-8	-8	-3	-4	-4	-3
3	Fire Service	-	-	-	-4	-8	-4	-4	-4	-8	-8	-4	-4	3	-8	-4	-3	-3	-3	-3	-8	-8	-3	-4	-4	-3
4	Car Call Cancellation	-	-	-	-	-2	-	-4	-	-	-	-	-4	-	-4	-4	-4	-9	-4	-	-	-	-9	-	-	-
5	Car Call Registration	-	-	-	-	-	1	-4	-	-	-	-1	-4	-1	-3	-4	-3	-9	-3	-	-	-	-9	-	-	-
6	Anti-Nuisance	-	-	-	-	-	-	-4	-	-	-	-	-4	-	-4	-4	-4	-9	-4	-	-	-	-	-	-9	-
7	Hall Call Registration	-	-	-	-	-	-	-	-	-	-	-	-4	-	-4	-4	-4	-9	-4	-	-	-	-	9	-	-
8	Auto Door Open	-	-	-	-	-	-	-	-	-	-4	-4	-	-	-	-	-	-	-	-9	-4	1	-	-	-	-
9	Door Open Button	-	-	-	-	-	-	-	-	-	-4	-4	-	-	-	-	-	-	-	-9	-4	1	-5	-	-	-
10	Auto Door Close	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-9	-4	1	-	-	-	-
11	Door Close Button	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-4	1	-5	-	-	-
12	Auto Start	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-9	-9	1	-	-	-	-	-
13	Call Button Start	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-5	-5	1	-	-5	-	-	-
14	Speed Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-9	-9	-	-	-	-	-	-
15	Load Weighing Bypass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-9	-9	-9	-	-	-	-	-9	-
16	Registered Floor Stop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-9	-9	-	1	-	-	-	-
17	Call Data Management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-4	-	-	-	-	-	-
18	Direction Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-14	-	-	-	-	-	-
19	Position Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-4	-	-	-	9
20	Car Move	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-	-	-	-
21	Car Stop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Car Button	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Hall Button	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Weight Sensor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Position Sensor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.6: ECS features Dependencies Weights for Pajek

	Number of clusters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Features	Cluster Results																								
1	Passenger Service	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	VIP Service	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	Fire Service	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	Car Call Cancellation	1	2	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	Car Call Registration	1	2	3	3	3	3	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	Anti-Nuisance	1	2	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	6	6	6	6
7	Hall Call Registration	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7	7
8	Auto Door Open	1	2	3	3	3	4	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	8	8
9	Door Open Button	1	2	3	3	3	4	5	7	6	6	7	7	6	7	6	7	7	7	7	7	7	8	8	9	9
10	Auto Door Close	1	2	3	4	4	5	6	8	5	7	8	8	7	8	7	8	8	8	8	8	8	9	9	10	10
11	Door Close Button	1	2	3	4	4	5	6	8	7	8	8	8	8	8	8	8	8	9	9	9	9	10	10	11	11
12	Auto Start	1	2	3	4	4	5	5	5	8	9	5	9	9	9	9	9	9	10	10	10	10	11	11	12	12
13	Call Button Start	1	2	3	4	4	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	11	12	12	13	13
14	Speed Control	1	2	3	4	4	5	5	8	8	7	9	7	6	10	10	10	10	11	11	11	12	13	13	14	14
15	Load Weighing Bypass	1	2	3	4	4	5	5	8	6	6	8	8	6	8	6	8	11	12	12	12	13	14	14	15	15
16	Registered Floor Stop	1	2	3	4	4	5	5	8	6	6	8	8	6	8	6	8	11	12	12	13	14	15	15	16	16
17	Call Data Management	1	1	2	2	5	4	6	6	9	10	9	6	10	11	11	11	12	13	13	14	15	16	16	17	17
18	Direction Control	1	1	2	3	3	6	7	7	7	8	7	10	11	12	12	12	13	14	14	15	16	17	17	18	18
19	Position Control	1	1	1	1	1	3	4	4	4	4	10	4	12	13	13	13	14	15	15	16	17	18	18	19	19
20	Car Move	1	2	1	4	5	6	7	5	8	9	5	9	9	9	9	14	15	10	16	17	18	19	19	20	20
21	Car Stop	1	2	3	3	4	5	5	8	6	6	8	8	6	8	6	8	8	16	17	18	19	20	20	21	21
22	Car Button	1	1	2	2	5	6	7	6	8	9	9	11	10	14	14	15	16	17	18	19	20	21	21	22	22
23	Hall Button	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23	23
24	Weight Sensor	1	1	1	3	5	4	4	6	9	1	1	12	13	11	15	16	17	18	19	20	21	22	22	24	24
25	Position Sensor	1	2	1	1	1	3	4	4	4	4	10	4	12	13	13	13	14	15	15	16	17	18	23	19	25
	error	713	220	103	54	35	26	20	18	18	18	18	18	18	18	18	19	20	21	22	24	27	31	40	51	60
	No. of solutions found	1	2	1	1	2	8	32	32	781	2275	2806	1842	569	64	2	7	11	6	1	1	1	1	1	2	1

Table 5.7: Pajek's Clustering Results for ECS product line Features

Feature #	Feature Name	Set #
1	Passenger Service	1
6	Anti-Nuisance	
7	Hall Call Registration	
23	Hall Button	
2	VIP Service	2
3	Fire Service	3
13	Call Button Start	
4	Car Call Cancellation	4
5	Car Call Registration	5
8	Auto Door Open	6
9	Door Open Button	
15	Load Weighing Bypass	
16	Registered Floor Stop	
21	Car Stop	
10	Auto Door Close	7
11	Door Close Button	8
12	Auto Start	9
20	Car Move	
14	Speed Control	10
17	Call Data Management	11
18	Direction Control	12
19	Position Control	13
25	Position Sensor	
22	Car Button	14
24	Weight Sensor	15

Table 5.8: ECS Features Sets

5.1.3 ECS Features Sets Reuse Opportunity Computing

In this section we compute the *ECS Features Sets Reuse Opportunity*. As presented in *Chapter 3*, there are three factors for feature *Reuse Opportunity*: *Feature Model Factor (FMF), MPP Factor (MPPF),* and *Dependency factor (DF)*. To compute *Features Set Reuse Opportunity* we need to compute each one of the previous three factors for each feature in *ECS*. The results of these computations are presented in *Appendix A*. The following sub-sections present and discuss the computation process of *ECS Features Sets Reuse Opportunity*.

- **Computing ECS Features Sets Feature Model Factor (FSFMF)**

  Before computing *FSFMF* we need to compute *FMF* for each *ECS* feature. These computations will be based on *Chapter 3*, equations (10) to (14). *Table A.4*; shows the results of these computations.

  Table 5.9; shows the results of *ECS* features *FT* and *Features Sets FSFMF*. From these results it be noticed that *FSFMF* value is based on the number of features within the *Features Set* and those features types.

- **Computing ECS Features Sets MPP Factor (FSMPPF)**

  To compute *FSMPPF* we first compute features *MPPF* based on information within *Table A.1*; and chapter 3 equations (15) to (19). *Table A.4*; shows *ECS* features *MPPF* results. From these results it can be seen that some *MPP* attributes and then their *MPP* sub-factor results related to feature type.

Then form these results we compute *FSMPPF* for each *ECS Features Set* based on *Chapter 3* equations (20) to (24). *Table 5.10*; presents the *ECS Features Sets FSMPPF* values.

- **Computing ECS Features Sets Dependency Factor (FSDF)**

ECS features dependencies values was computes through the classification process based on *Chapter 3* equations (25), (26), and (27). Here we compute dependencies factors (*DF*) and internal dependencies factors (*IDF*) for each *Features Set* in *ECS*. *Table A.4*; shows *ECS* features *DF* and *IDF* results. And the results of computing *FSDF* for ECS *Features Sets* are shown in *Table 5.11*. These computations also based on the previous equations (25), (26), and (27) in *Chapter 3*. As these results shown the value of each one of *DF*, *IDF*, and *FSDF* is based on the number of *Features Set's* features and these features' relations number.

- **Computing ECS Features Sets Reuse Opportunity (FSRO)**

Finally, we can use the equation (28) in *Chapter 3*; to compute *ECS Features Sets Reuse Opportunity* (*FSRO*). *Table 5.12*; shows the computations results of *ECS Features Sets FSRO*.

Feature #	Features	Set #	*FM Factor* *FT*	*FSFMF*
1	Passenger Service	1	1	0.875
6	Anti-Nuisance		0.5	
7	Hall Call Registration		1	
23	Hall Button		1	
2	VIP Service	2	0.5	0.5
3	Fire Service	3	0.5	0.5
13	Call Button Start		0.5	
4	Car Call Cancellation	4	0.5	0.5
5	Car Call Registration	5	1	1
8	Auto Door Open	6	1	0.9
9	Door Open Button		1	
15	Load Weighing Bypass		0.5	
16	Registered Floor Stop		1	
21	Car Stop		1	
10	Auto Door Close	7	1	1
11	Door Close Button	8	1	1
12	Auto Start	9	1	1
20	Car Move		1	
14	Speed Control	10	1	1
17	Call Data Management	11	1	1
18	Direction Control	12	1	1
19	Position Control	13	1	1
25	Position Sensor		1	
22	Car Button	14	1	1
24	Weight Sensor	15	0.5	0.5
System				0.86

Table 5.9: FSFMF of Features Sets in ECS

Feature #	Features	Set #	Features Sets MPP Factors				FSMPPF
			FSNA	FSPR	FSFC	FSBT	
1	Passenger Service	1	0.9375	0.0503195	0.9925	0.875	0.7138299
6	Anti-Nuisance						
7	Hall Call Registration						
23	Hall Button						
2	VIP Service	2	0.53	0.0750799	0.2	0.5	0.32626997
3	Fire Service	3	0.6	0.01877	0.66	0.5	0.4446925
13	Call Button Start						
4	Car Call Cancellation	4	0.7	0.0455272	0.67	0.5	0.47888179
5	Car Call Registration	5	1	0.0127796	1	1	0.75319489
8	Auto Door Open	6	0.902	0.0410543	0.906	0.9	0.6872636
9	Door Open Button						
15	Load Weighing Bypass						
16	Registered Floor Stop						
21	Car Stop						
10	Auto Door Close	7	1	0.0734824	1	1	0.76837061
11	Door Close Button	8	1	0.048722	1	1	0.76218051
12	Auto Start	9	1	0.0383387	1	1	0.7595847
20	Car Move						
14	Speed Control	10	1	0.0247604	1	1	0.7561901
17	Call Data Management	11	1	0.0167732	1	1	0.75419329
18	Direction Control	12	1	0.028754	1	1	0.7571885
19	Position Control	13	1	0.0471246	1	1	0.7617812
25	Position Sensor						
22	Car Button	14	1	0.0159744	1	1	0.75399361
24	Weight Sensor	15	0.54	0.043131	0.83	0.5	0.47828275
System			0.8892	1	0.9008	0.86	0.9125

Table 5.10: ECS Features Sets MPP Factors Values and FSMPPF Values

Feature #	Features	Set #	*DF*	*IDF*	*FSDF*
1	Passenger Service	1	1	0.1428571	0.281746
6	Anti-Nuisance		0.4583333	0.0952381	
7	Hall Call Registration		0.5416667	0.1428571	
23	Hall Button		0.1666667	0.0952381	
2	VIP Service	2	1	0	0.1666667
3	Fire Service	3	1	0.0434783	0.1941425
13	Call Button Start		0.2083333	0	
4	Car Call Cancellation	4	0.5	0	0.0833333
5	Car Call Registration	5	0.6666667	0	0.1111111
8	Auto Door Open	6	0.2916667	0	0.2555556
9	Door Open Button		0.2916667	0	
15	Load Weighing Bypass		0.4583333	0.05	
16	Registered Floor Stop		0.375	0.1	
21	Car Stop		0.4166667	0.15	
10	Auto Door Close	7	0.3333333	0	0.0555556
11	Door Close Button	8	0.3333333	0	0.0555556
12	Auto Start	9	0.4166667	0.0869565	0.1240942
20	Car Move		0.4583333	0.0434783	
14	Speed Control	10	0.4166667	0	0.0694444
17	Call Data Management	11	0.7916667	0	0.1319444
18	Direction Control	12	0.6666667	0	0.1111111
19	Position Control	13	0.9583333	0.0434783	0.151872
25	Position Sensor		0.0833333	0.0869565	
22	Car Button	14	0.2916667	0	0.0486111
24	Weight Sensor	15	0.25	0	0.0416667
System					0

Table 5.11: Features Sets Dependencies Factors in ECS

Feature #	Features	Set #	*Reuse Opportunity Factors*			*FSRO*
			FSFMF	*FSMPPF*	*FSDF*	
1	Passenger Service	1	0.875	0.7138299	0.281746	1.870575904
6	Anti-Nuisance					
7	Hall Call Registration					
23	Hall Button					
2	VIP Service	2	0.5	0.32626997	0.1666667	0.992936635
3	Fire Service	3	0.5	0.4446925	0.1941425	1.138835004
13	Call Button Start					
4	Car Call Cancellation	4	0.5	0.47888179	0.0833333	1.062215122
5	Car Call Registration	5	1	0.75319489	0.1111111	1.864305999
8	Auto Door Open	6	0.9	0.6872636	1.7833333	3.370596912
9	Door Open Button					
15	Load Weighing Bypass					
16	Registered Floor Stop					
21	Car Stop					
10	Auto Door Close	7	1	0.76837061	0.0555556	1.823926163
11	Door Close Button	8	1	0.76218051	0.0555556	1.817736067
12	Auto Start	9	1	0.7595847	0.1240942	1.883678867
20	Car Move					
14	Speed Control	10	1	0.7561901	0.0694444	1.82563454
17	Call Data Management	11	1	0.75419329	0.1319444	1.886137735
18	Direction Control	12	1	0.7571885	0.1111111	1.86829961
19	Position Control	13	1	0.7617812	1.0199275	2.781708686
25	Position Sensor					
22	Car Button	14	1	0.75399361	0.0486111	1.802604721
24	Weight Sensor	15	0.5	0.47828275	0.0416667	1.019949414
System[14]			0.86	0.9125	0	1.7725

Table 5.12: FSRO of Features Sets in ECS

[14] *We count the whole system as a Features Set contains all system features.*

5.1.4 ECS Features Sets Options Analysis

In this phase we use *ROT* concepts to prioritize *ECS Features Sets* for the system core asset development. The *Black-Scholes* and *Chooser Option* formulas used to value the *Features Sets* as options. As discussed in *Chapter 3*, this phase includes two steps: *Reuse Opportunity Valuation and Features Sets Development Priority*. The coming sub-sections show these steps results and the results discussions.

- **ECS Features Sets Reuse Opportunities Valuations**

  To calculate *Features Sets* pricing we use *Chapter 3's* equations, i.e. equation (28) for *Call Option Pacing*, equation (29) for *Put Option Pricing*, and equation (30) for *Chooser Option Pricing*. These equations are computed for each *ECS Features Set Reuse Opportunity* which is counted as an option. We start these calculations by equations' parameters initialization as shown below:

  S = FSRO (A_i), (Reuse Opportunity value of ECS's *Features Set A_i, i = 1 to N, N = 15, Number of ECS Features Sets*).

  X^{15} *= FSRO(System) = 1.7551, (Reuse Opportunity* value of *ECS* system).

  $r = 1\%$.

  $\sigma = 25\%$.

  $T = N - 1 = 15 - 1 = 14$, (*Available remaining iterations after the development of the Features Set A*).

  $T_2 = T = 14$.

  $t_1 = 1$, *(i.e. each Features Set will be developed at one iteration).*

[15] *We also compute option prices for ECS Features Sets without using the system Reuse Opportunity, i.e. X = S = FSRO(Features Set). The results and discussions of these computations are shown in Appendix A.*

Using *S = FSRO(Features Set)* and *X = FSRO(whole system)* means that the choice is between *Features Set* development and whole system development at the current development iteration with respect to other equation's parameters.

After the initialization process we calculate the results of each option. *Table 5.13*; shows the results of *ECS Features Sets Options Prices*.

Form the results shown in *Table 5.13*; we notice that *Call Option Price* (*i.e. choice of develop*) of any *Features Set* is *larger* than its *Put Option Price* (*i.e. choice of postpone*), when its *Reuse Opportunity* is *larger* than (*or equal to*) the *Reuse Opportunity* of the whole system. Also, we can notice that the *Chooser Option Price* of any *Features Set* is follow its largest value of its *Call* or *Put Price*, which gives an indication to the best choice that should be *Call* or *Put* for any *Features Set*.

- **ECS Features Sets Development Priorities**

In this step we put the results of *ECS Features Sets Options Valuations* in the order based on their values starting from the *largest* to the *smallest*. This order shows the *Development Priority* of each *ECS Features Set*.

In addition to the previous notes, it is clear from the results shown in *Table 5.13*; that *Features Set* that has the *largest Call Option Price*, also has the *smallest Put Option Price*. This means it has the *largest* priority to be developed at the *earliest* development iterations and the *smallest* priority to be postponed to *latest* development iterations.

Table 5.14; shows the *ECS Features Sets* development priorities. And *Figure 5.4*; shows the relation between *Reuse Opportunities, Call Option Prices, Put Option Prices,* and *Chooser Option Prices* of *ECS Features Sets*.

We also, calculate the options prices of each *ECS* feature (i.e. without classification into *Features Sets*). The computation results are shown in *Table 5.15*. It is clear that what we said about *ECS Features Sets Options Analysis* is also, true when we use *features* instead of *Features Sets*. *Figure 5.5*; shows the *ECS* features options analysis.

In addition to the previous computations, we compute option prices for ECS features and ECS Features Sets without using the system Reuse Opportunity, i.e. S = X = FSOR(Features Set), (or S = X = FRO(Feature) when the computations are for features). The results and discussions of these computations are shown in Appendix A.

Feature #	Features	Set #	*Option Pricing Parameters*				Option Price		
			FSRO	***r***	***σ***	***T***	**Call**	**Put**	**Option Value**
1	Passenger Service	1	1.8705759	1%	25%	14	0.75814280	0.51376747	0.83626698
6	Anti-Nuisance								
7	Hall Call Registration								
23	Hall Button								
2	VIP Service	2	0.99293663				0.40243636	0.27271737	0.44390613
3	Fire Service	3	1.138835				0.46156885	0.31278943	0.50913203
13	Call Button Start								
4	Car Call Cancellation	4	1.06221512				0.43051487	0.29174522	0.47487805
5	Car Call Registration	5	1.864306				0.75560162	0.51204539	0.83346393
8	Auto Door Open	6	3.37059691				1.36610003	0.92575930	1.50687223
9	Door Open Button								
15	Load Weighing Bypass								
16	Registered Floor Stop								
21	Car Stop								
10	Auto Door Close	7	1.82392616				0.73923570	0.50095477	0.81541156
11	Door Close Button	8	1.81773607				0.73672686	0.49925462	0.81264419
12	Auto Start	9	1.88367887				0.76345342	0.51736629	0.84212484
20	Car Move								
14	Speed Control	10	1.82563454				0.73992811	0.50142399	0.81617531
17	Call Data Management	11	1.88613774				0.76445000	0.51804164	0.84322411
18	Direction Control	12	1.86829961				0.75722022	0.51314227	0.83524933
19	Position Control	13	2.78170869				1.12742414	0.76401681	1.24360156
25	Position Sensor								
22	Car Button	14	1.80260472				0.73059414	0.49509868	0.80587951
24	Weight Sensor	15	1.01994941				0.41338462	0.28013663	0.45598257
	System		1.7725						

Table 5.13: Options Prices of ECS's Features Sets

Feature #	Features	Set #	Options	Option Price			Development Priority
			ROFS	Call	Put	Option Value	
8 9 15 16 21	Auto Door Open Door Open Button Load Weighing Bypass Registered Floor Stop Car Stop	6	3.370596912	2.06433955	0.21955328	2.06445474	1st
19 25	Position Control Position Sensor	13	2.781708686	1.54168061	0.28578257	1.54305431	2nd
17	Call Data Management	11	1.886137735	0.80882013	0.44849304	0.85531364	3rd
12 20	Auto Start Car Move	9	1.883678867	0.80696112	0.44909289	0.85386226	4th
1 6 7 23	Passenger Service Anti-Nuisance Hall Call Registration Hall Button	1	1.870575904	0.79707289	0.45230763	0.84620087	5th
18	Direction Control	12	1.86829961	0.79535822	0.45286925	0.84488256	6th
5	Car Call Registration	5	1.864305999	0.79235220	0.45385684	0.84257887	7th
14	Speed Control	10	1.82563454	0.76339512	0.46357121	0.82089609	8th
10	Auto Door Close	7	1.823926163	0.76212230	0.46400677	0.81996516	9th
11	Door Close Button	8	1.817736067	0.75751500	0.46558957	0.81661175	10th
22	Car Button	14	1.802604721	0.74628336	0.46948928	0.80854666	11th
3 13	Fire Service Call Button Start	3	1.138835004	0.30755832	0.69453395	0.71403412	12th
4	Car Call Cancellation	4	1.062215122	0.26564619	0.72924171	0.73962473	13th
24	Weight Sensor	15	1.019949414	0.24352040	0.74938162	0.75637696	14th
2	VIP Service	2	0.992936635	0.22976843	0.76264244	0.76796940	15th

Table 5.14: Development Priority of ECS Features Sets

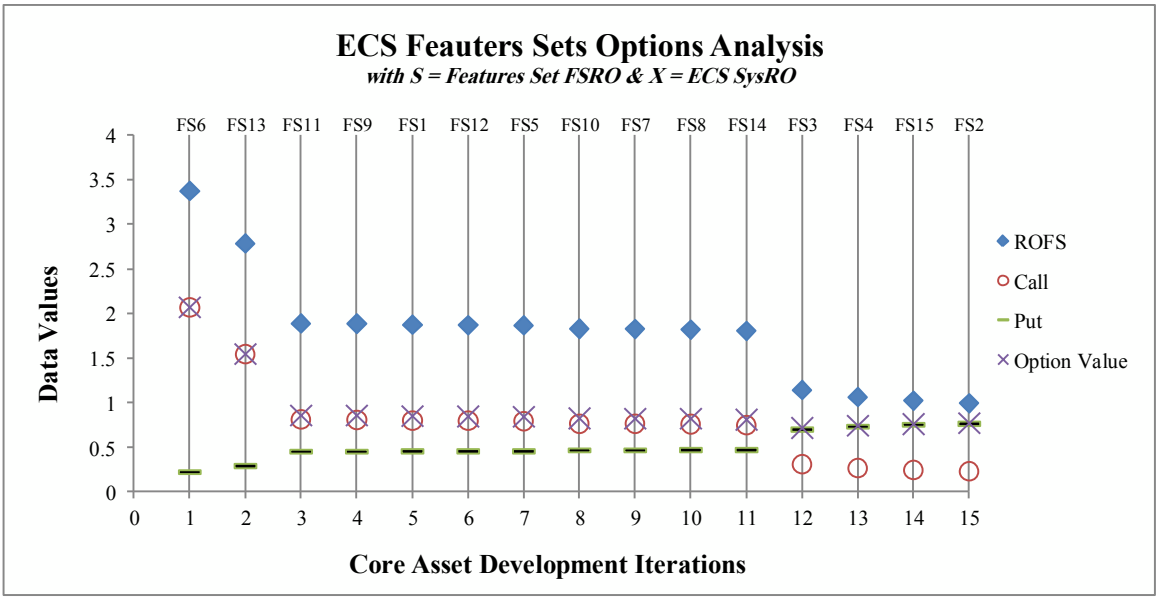

Figure 5.4: ECS Features Sets Options Analysis

Feature #	Features	Options	Option Price			Development Priority
		ROFS	Call	Put	Option Value	
1	Passenger Service	2.7641773	1.769549	0.385983	1.769945	1st
22	Car Button	2.7131257	1.724659	0.392144	1.72516	2nd
20	Car Move	2.54586	1.578724	0.413475	1.579813	3rd
21	Car Stop	2.4238552	1.473483	0.430239	1.475389	4th
9	Door Open Button	2.4198616	1.470057	0.430806	1.471997	5th
3	Fire Service	2.3004526	1.368184	0.448342	1.37152	6th
18	Direction Control	2.213525	1.294764	0.46185	1.299691	7th
17	Call Data Management	2.1806443	1.267167	0.467133	1.272869	8th
14	Speed Control	2.1776491	1.264657	0.467619	1.270437	9th
19	Position Control	2.1728568	1.260645	0.468398	1.266548	10th
13	Call Button Start	2.144369	1.236835	0.473077	1.243531	11th
15	Load Weighing Bypass	2.1017039	1.201321	0.480227	1.209398	12th
16	Registered Floor Stop	2.0955138	1.196183	0.481279	1.204482	13th
10	Auto Door Close	2.0476571	1.156589	0.489543	1.166811	14th
24	Weight Sensor	2.0456603	1.154943	0.489893	1.165253	15th
11	Door Close Button	2.0448616	1.154284	0.490033	1.16463	16th
6	Anti-Nuisance	2.0344968	1.145742	0.491856	1.156563	17th
4	Car Call Cancellation	1.926451	1.057389	0.511549	1.074553	18th
23	Hall Button	1.8521033	0.99736	0.525868	1.020767	19th
5	Car Call Registration	1.82627	0.976658	0.530999	1.002689	20th
2	VIP Service	1.5309052	0.746448	0.596153	0.828131	21st
8	Auto Door Open	1.4788818	0.707296	0.609024	0.805595	22nd
12	Auto Start	1.3551145	0.616116	0.641612	0.765206	23rd
25	Position Sensor	1.2282827	0.525886	0.678214	0.745566	24th
7	Hall Call Registration	1.0632215	0.414152	0.731541	0.754523	25th
	System	1.7725				

Table 5.15: Options Prices and Development Priorities of ECS's Features

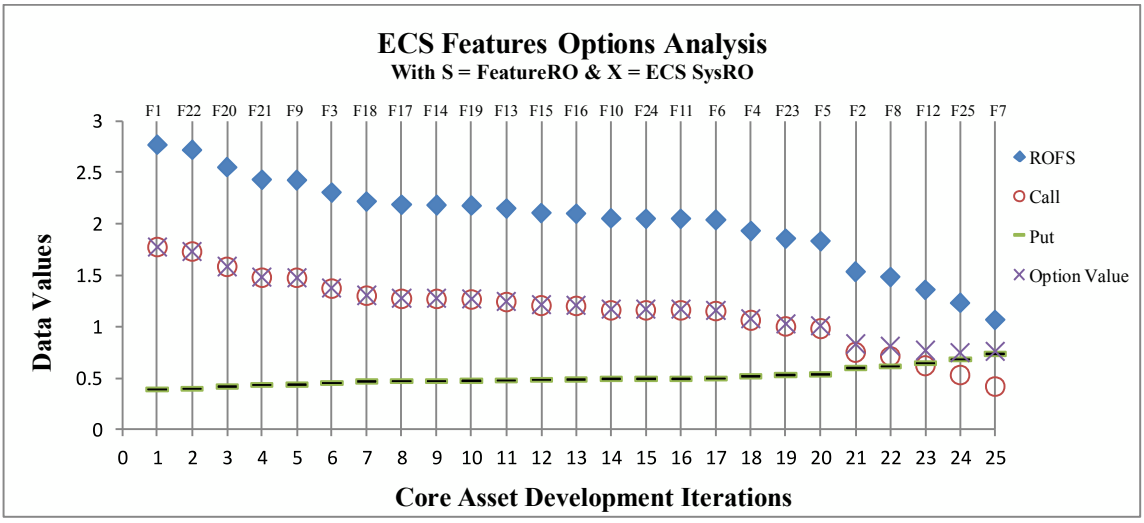

Figure 5.5: ECS Features Options Analysis

5.2 Scientific Calculator System (SCS)

This section shows the result of application of our framework on the *SCS* product line. The results from each step of the framework phases are presented and discussed.

5.2.1 SCS Features Dependency Analysis

As shown in *Chapter 3;* and as we do for the previous case study this phase contains three steps: *Feature Model Analysis, Operational Dependency Analysis,* and *Activation Dependency Analysis*. The results of each step are shown and discussed in the following sub-sections.

- **SCS Feature Model Analysis**

We analyze *SCS Feature Model*, which is shown in *Chapter 4*, to identify the *Operational Features* and theirs types. As shown in *Table 5.16*; there are *86 Operational Features* in *SCS*, *48* of them are optional features and the rest *38* are common features.

Feature #	Features	*Feature Type*		Feature #	Features	*Feature Type*
1	Standard	Common		44	Binary	Optional
2	Scientific	Optional		45	Octane	Optional
3	Programmer	Optional		46	Hexadecimal	Optional
4	Statistics	Optional		47	Binary number set	Optional
5	Display	Common		48	Octane number Set	Optional
6	Clearing	Common		49	Decimal Number Set	Common
7	Systems	Optional		50	Decimal Point	Common
8	Size	Common		51	Letter Numbers	Optional
9	Angle	Optional		52	Byte Number Set	Common
10	Basic Notation	Common		53	Word Number Set	Common
11	Scientific Notation	Optional		54	Dword Number Set	Optional
12	Memory	Optional		55	Qword Number Set	Optional
13	History	Optional		56	Pi	Common
14	Binary Operations	Common		57	2Pi	Optional
15	Unique Operations	Optional		58	Byte	Common
16	Exp Functions & Log	Common		59	Word	Common
17	Ln	Optional		60	Dword	Optional
18	e Function	Optional		61	Qword	Optional
19	n!	Optional		62	Degrees	Common
20	SCTH Functions	Common		63	Radians	Optional
21	SCTHI Functions	Optional		64	Grads	Optional
22	Basic Boolean Operation	Common		65	Enable Calculator Functions	Common
23	Extra Boolean Operation	Optional		66	Disable Calculator Functions	Optional
24	Statistics Operations	Optional		67	Inverse-On	Optional
25	Percentage (%)	Common		68	Inverse--Off	Common
26	Mod	Common		69	Equal	Common
27	Int & Dms	Optional		70	Sign	Common
28	Frac & Deg	Optional		71	Arcs	Optional
29	Inputs display	Common		72	Scientific Notation Editing	Optional
30	Operations Results Display	Common		73	Add	Common
31	Error messages Display	Optional		74	Result Foundation	Common
32	Operations History Display	Optional		75	Unexpected Input Handling	Optional
33	Binary Numbers Display	Optional		76	Error Notification	Common
34	Statistics Data Display	Optional		77	Parsing	Common
35	C	Common		78	Number Conversion	Common
36	CE	Optional		79	Calc Buttons	Common
37	Backspace	Optional		80	Systems Selection Buttons	Optional
38	CAD	Optional		81	Size Selection Buttons	Optional
39	Error Clearing	Common		82	Display Box	Common
40	Memory Store	Common		83	History Dialog Box	Optional
41	Memory Recall	Common		84	Statistics Dialog Box	Optional
42	Memory Clear	Common		85	Binary Numbers Dialog Box	Optional
43	Decimal	Common		86	Menu	Optional

Table 5.16: SCS Operational Features and Features Types

- **SCS Features Operational Dependency Analysis**

As discussed in *Chapter 3*, and as we do for the previous case study the *Operational Dependencies* (i.e. *Usage* dependency and *Modification* dependency) of *SCS* features are analyzed. The results of operational dependency analysis of *SCS*[16] features show that we have four diving services (i.e. *Standard Calc, Scientific Calc, Programmer Calc,* and *Statistics Calc*) as only one of them can be provided at a time. The *Operational Dependencies* between *SCS* features can be seen in *Figure 5.6*; and *Figure 5.7*; which show the *Operational Dependencies* analysis results of *SCS* features.

[16] Small p*art of operational dependency and small part of activation dependencies of SCS system (contains less than 20 features) were appeared in [54, 59] and others.*

- **SCS Features Activation Dependency Analysis**

In the *SCS* system there will be some features (*a subordinate*) that can be active during the activation of another feature. And they will not be activated if their *superior* is not active. They may be exist a feature that has more than one superior which means it can be activated if any one of them is active (*Calc Buttons* can be active during the activation of any one of the four calculator type.

As in *SCS* one driving service (*feature*) can be provided at a time which means features *Standard Calc, Scientific Calc, Programmer Calc,* and *Statistics Calc* have *Exclusive-Activation* dependencies with each other. This means they cannot be active at the same time. There are some other features that must be activated concurrently at a time (e.g. *Result Foundation* has *Concurrent-Activation* with *Binary Operations, Unique Operations, Boolean Operations*, and others).

A complete picture of *SCS* features *Activation Dependencies* can be seen in *Figure 5.8*; *Figure 5.9*; and *Figure 5.10*. *Table 5.17* to *Table 5.25*; summarize the dependencies relations between *SCS* features.

As we do for the previous case study and based on *equations* (*4*) to (*9*) in *Chapter 3*, *Table 5.26*; shows the total numbers of dependencies relations for each feature in *SCS* system.

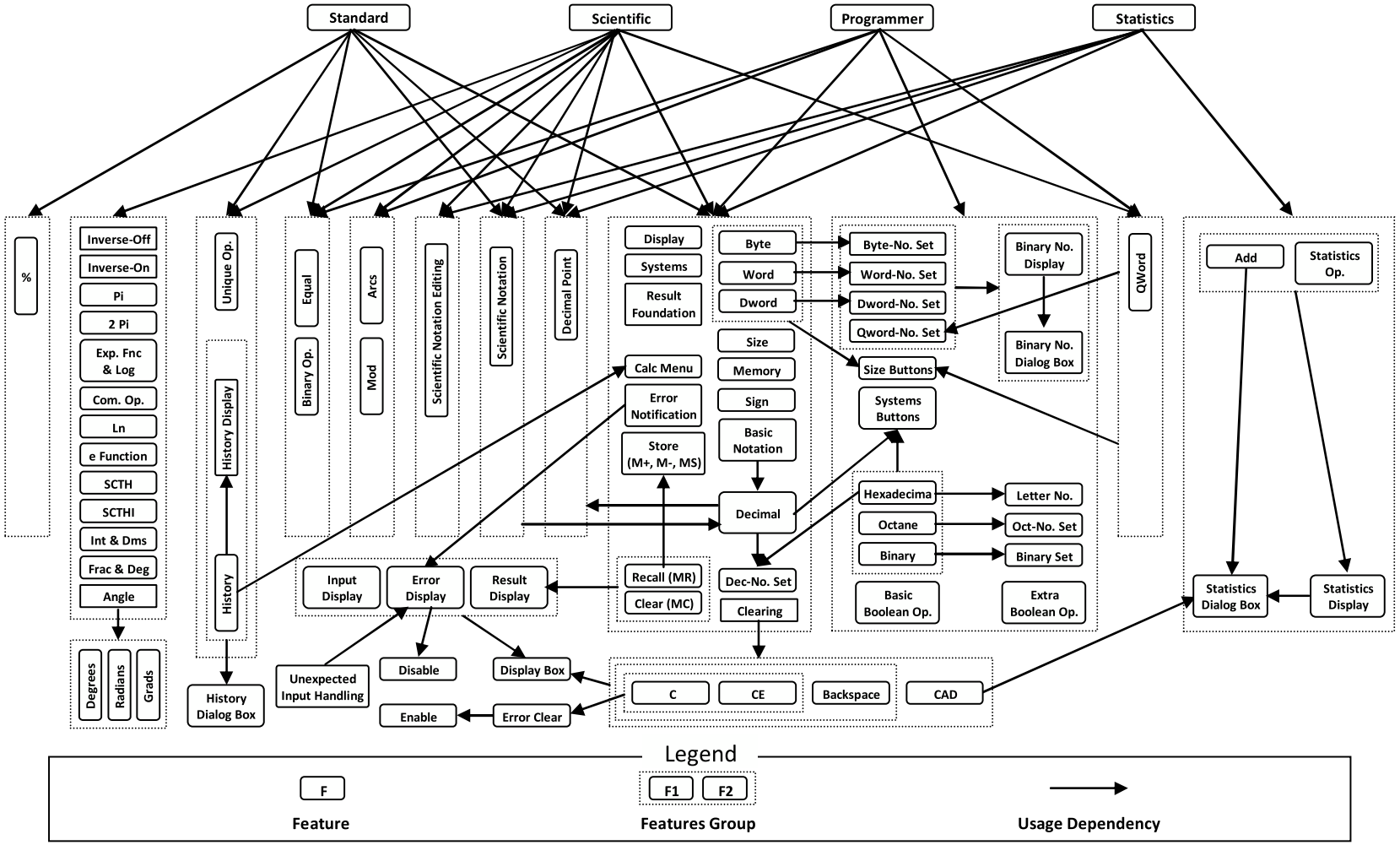

Figure 5.6: Features Operational Dependency in the SCS product line (Usage Dependency – Part 1)

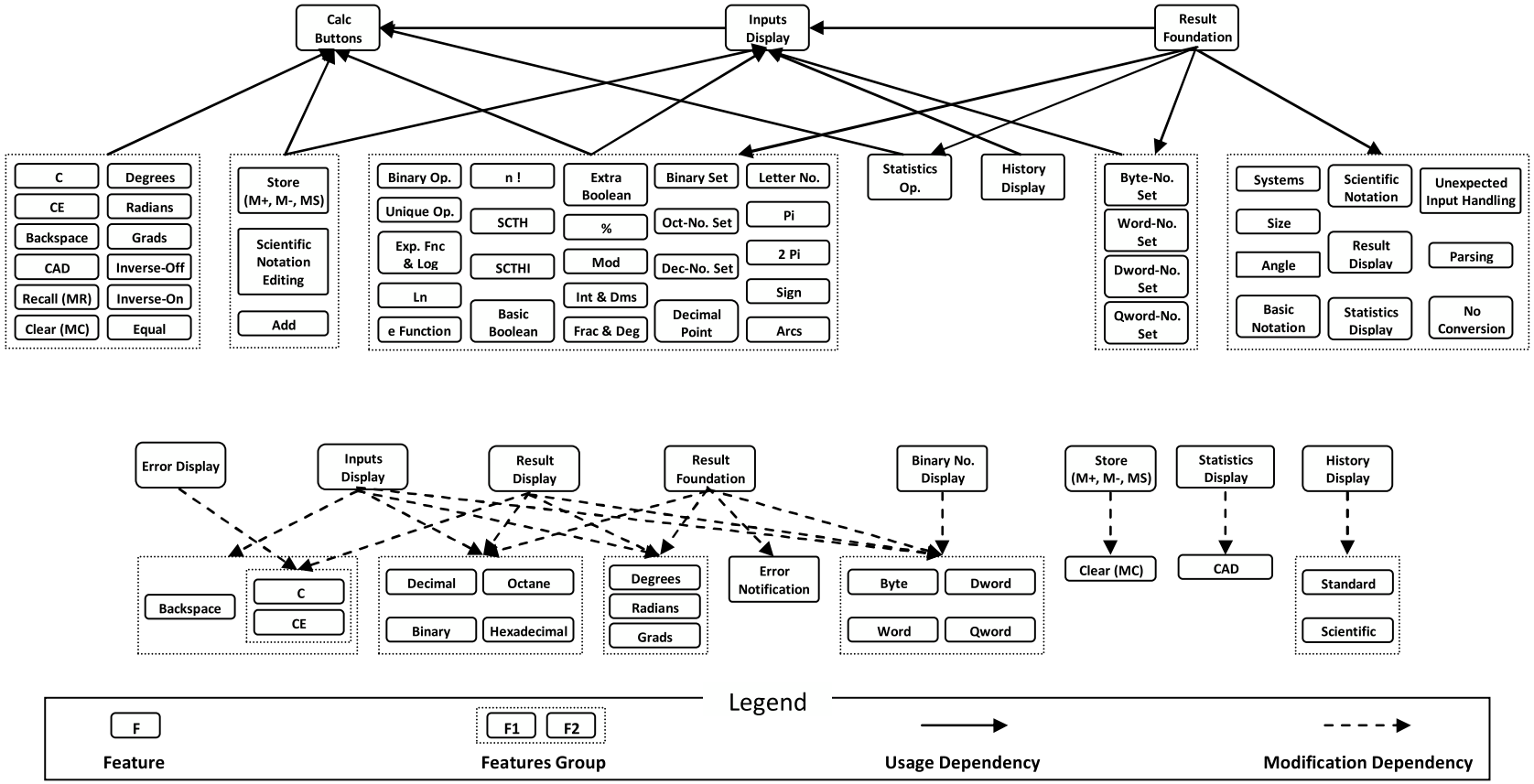

Figure 5.7: Features Operational Dependency in the SCS product line (Usage Dependency – Part 2 & Modification Dependency)

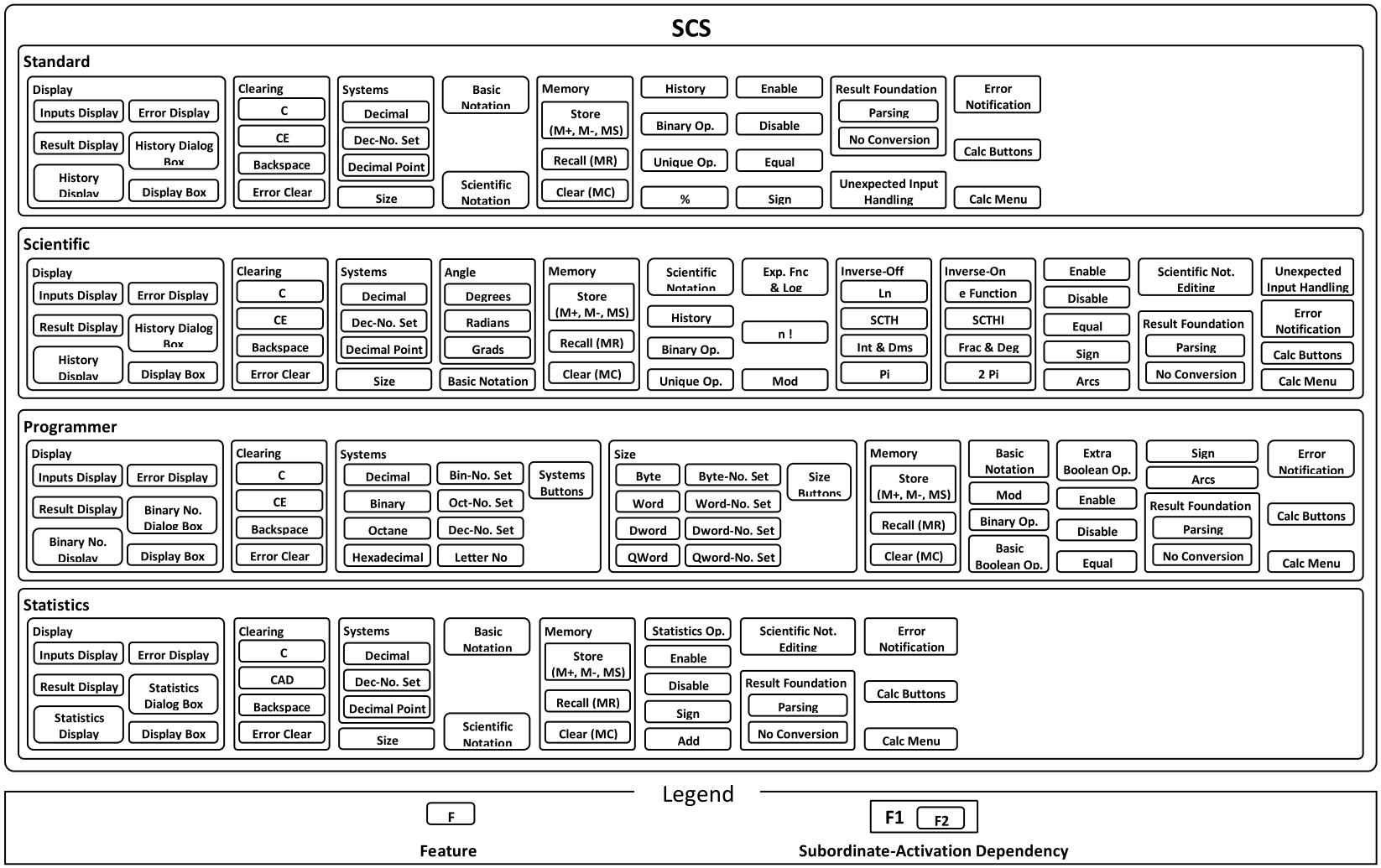

Figure 5.8: Features Activation Dependency in the SCS product line (Subordinate-Activation)

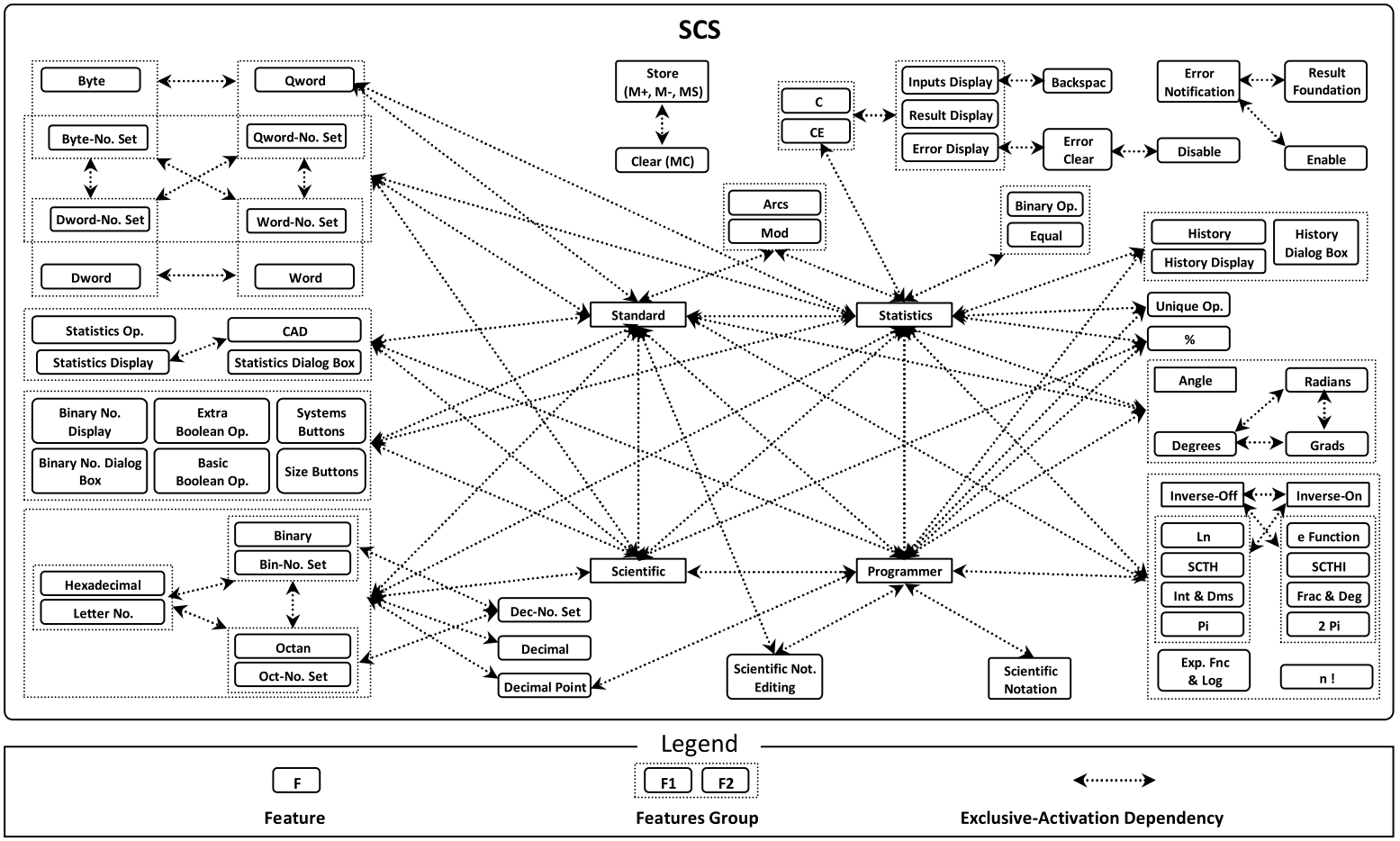

Figure 5.9: Features Activation Dependency in the SCS product line (Exclusive-Activation)

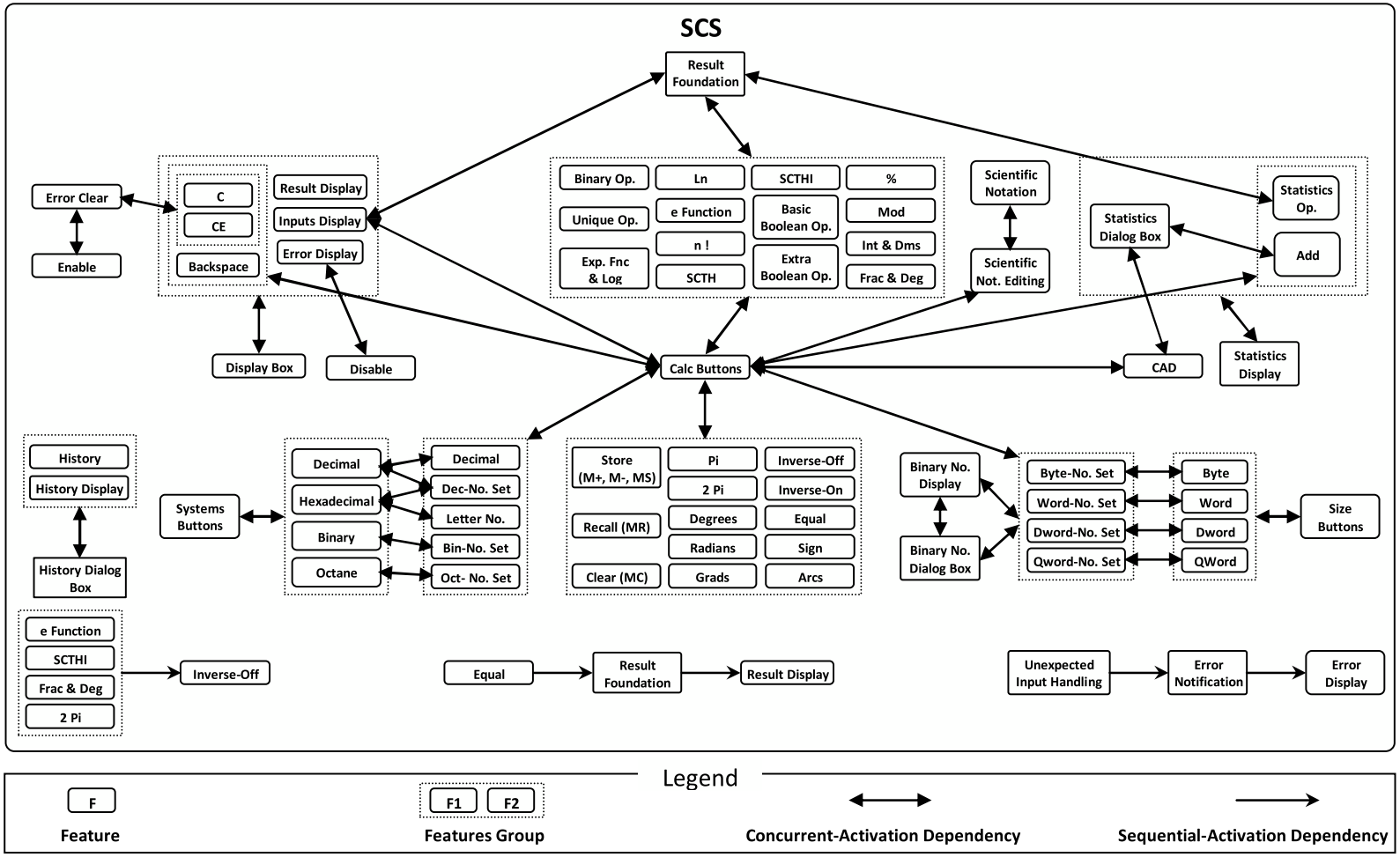

Figure 5.10: Features Activation Dependency in the SCS product line (Concurrent-Activation and Sequential-Activation)

	Feature	1 Standard	2 Scientific	3 Programmer	4 Statistics	5 Display	6 Clearing	7 Systems	8 Size	9 Angle	10 Basic Notation	11 Scientific Notation	12 Memory	13 History	14 Binary Operations	15 Unique Operations	16 Exp Functions & Log	17 Ln	18 e Function	19 n!	20 SCTH Functions	21 SCTHI Functions	22 Basic Boolean Operation	23 Extra Boolean Operation	24 Statistics Operations	25 Percentage (%)	26 Mod	27 Int & Dms	28 Frac & Deg
1	Standard	-	E	E	E	S	S	S	S	E	S	S	S	S	S	S	E	E	E	E	E	E	E	E	E	S	E	E	E
2	Scientific	E	-	E	E	S	S	S	S	S	S	S	S	S	S	S	S			S			E	E	E	E	S		
3	Programmer	E	E	-	E	S	S	S	S	E	S	E	S	E	S	E	E	E	E	E	E	E	S	S	E	E	S	E	E
4	Statistics	E	E	E	-	S	S	S	S	E	S	S	S	E	E	E	E	E	E	E	E	E	E	E	S	E	E	E	E
5	Display	U	U	U	U	-																							
6	Clearing	U	U	U	U		-																						
7	Systems	U	U	U	U			-																					
8	Size	U	U	U	U				-																				
9	Angle	E	U	E	E					-																			
10	Basic Notation	U	U	U	U						-																		
11	Scientific Notation	U	U	E	U							-																	
12	Memory	U	U	U	U								-																
13	History	U	U	E	E									-															
14	Binary Operations	U	U	U	E										-														
15	Unique Operations	U	U	E	E											-													
16	Exp Functions & Log	E	U	E	E												-												
17	Ln	E	U	E	E													-											
18	e Function	E	U	E	E														-										
19	n!	E	U	E	E															-									
20	SCTH Functions	E	U	E	E																-								
21	SCTHI Functions	E	U	E	E																	-							
22	Basic Boolean Operation	E	E	U	E																		-						
23	Extra Boolean Operation	E	E	U	E																			-					
24	Statistics Operations	E	E	E	U																				-				
25	Percentage (%)	U	E	E	E																					-			
26	Mod	E	U	U	E																						-		
27	Int & Dms	E	U	E	E																							-	
28	Frac & Deg	E	U	E	E																								-

Table 5.17: SCS Features Operational and Activation Dependencies

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
1	Standard				M	E	E				E						E	E	E	E	E			E	E	E	E	E	E	E
2	Scientific				M	E	E				E						E	E	E	E	E			E	E	E	E	E		
3	Programmer				E		E				E												E						E	E
4	Statistics				E	E			E								E	E	E	E	E			E	E	E	E	E	E	E
5	Display	S	S	S	S	S	S																							
6	Clearing							S	S	S	S	S																		
7	Systems															S	S	S	S	S	S	S	S	S						
8	Size																								S	S	S	S		
9	Angle																													
10	Basic Notation																													
11	Scientific Notation																													
12	Memory												S	S	S															
13	History																													
14	Binary Operations																													
15	Unique Operations																													
16	Exp Functions & Log																													
17	Ln																													
18	e Function																													
19	n!																													
20	SCTH Functions																													
21	SCTHI Functions																													
22	Basic Boolean Operation																													
23	Extra Boolean Operation																													
24	Statistics Operations						C																							
25	Percentage (%)																													
26	Mod																													
27	Int & Dms																													
28	Frac & Deg																													

Table 5.18: SCS Features Operational and Activation Dependencies (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
1	Standard				E				S	S			S	S	E	E		S	S	S			S	E	E			E	E	S
2	Scientific								S	S	S	S	S	S	S	S		S	S	S			S	E	E			E	E	S
3	Programmer								S	S			S	S	S	E		S		S			S				E	E		S
4	Statistics				E				S	S			E	S	E	S	S	S		S			S	E	E		E		E	S
5	Display																									S	S	S	S	
6	Clearing																													
7	Systems																	U						S						
8	Size	S	S	S	S													U							S					
9	Angle					S	S	S										U												
10	Basic Notation																	U												
11	Scientific Notation															C		U												
12	Memory																													
13	History																										C			
14	Binary Operations																	UC					C							
15	Unique Operations																	UC					C							
16	Exp Functions & Log																	UC					C							
17	Ln										E							UC					C							
18	e Function											QE						UC					C							
19	n!																	UC					C							
20	SCTH Functions										E							UC					C							
21	SCTHI Functions											QE						UC					C							
22	Basic Boolean Operation																	UC					C							
23	Extra Boolean Operation																	UC					C							
24	Statistics Operations																	UC					C							
25	Percentage (%)																	UC					C							
26	Mod																	UC					C							
27	Int & Dms										E							UC					C							
28	Frac & Deg											QE						UC					C							

Table 5.19: SCS Features Operational and Activation Dependencies (Cont…)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
29	Inputs Display														U	U	U	U	U	U	U	U	U	U		U	U	U	U
30	Operations Results Display																												
31	Error messages Display																												
32	Operations History Display	U	U	E	E									U															
33	Binary Numbers Display	E	E	U	E																								
34	Statistics Data Display	E	E	E	U																				UC				
35	C						U																						
36	CE				E		U																						
37	Backspace						U																						
38	CAD	E	E	E			U																						
39	Error Clearing																												
40	Memory Store	U	U	U	U																								
41	Memory Recall	U	U	U	U																								
42	Memory Clear	U	U	U	U																								
43	Decimal	U	U	U	U						U	U																	
44	Binary	E	E	U	E																								
45	Octane	E	E	U	E																								
46	Hexadecimal	E	E	U	E																								
47	Binary number set	E	E	U	E																								
48	Octane number Set	E	E	U	E																								
49	Decimal Number Set	U	U	U	U																								
50	Decimal Point	U	U	E	U																								
51	Letter Numbers	E	E	U	E																								
52	Byte Number Set	E	E	U	E																								
53	Word Number Set	E	E	U	E																								
54	Dword Number Set	E	E	U	E																								
55	Qword Number Set	E	E	U	E																								
56	Pi	E	U	E	E																								
57	2Pi	E	U	E	E																								

Table 5.20: SCS Features Operational and Activation Dependencies (Cont…)

	Feature	29 Inputs Display	30 Operations Results Display	31 Error messages Display	32 Operations History Display	33 Binary Numbers Display	34 Statistics Data Display	35 C	36 CE	37 Backspace	38 CAD	39 Error Clearing	40 Memory Store	41 Memory Recall	42 Memory Clear	43 Decimal	44 Binary	45 Octane	46 Hexadecimal	47 Binary number set	48 Octane number Set	49 Decimal Number Set	50 Decimal Point	51 Letter Numbers	52 Byte Number Set	53 Word Number Set	54 Dword Number Set	55 Qword Number Set	56 Pi	57 2Pi
29	Inputs Display	-			U			E	E	E			U							U	U	U	U	U	U	U	U	U	U	U
30	Operations Results Display		-		U			E	E					U	U															
31	Error messages Display			-				E	E			E																		
32	Operations History Display				-																									
33	Binary Numbers Display					-																			UC	UC	UC	UC		
34	Statistics Data Display						-				E																			
35	C	ME	ME	ME				-				C																		
36	CE	ME	ME	ME					-			C																		
37	Backspace	ME								-																				
38	CAD						ME				-																			
39	Error Clearing			E				UC	UC			-																		
40	Memory Store												-	U	E															
41	Memory Recall													-																
42	Memory Clear												ME		-															
43	Decimal	M	M													-	E	E	E	E	E	C	C	E						
44	Binary	M	M													E	-	E	E	C	E	E	E	E						
45	Octane	M	M													E	E	-	E	E	C	E	E	E						
46	Hexadecimal	M	M													E	E	E	-	E	E	C	E	C						
47	Binary number set															E	UC	E	E	-										
48	Octane number Set															E	E	UC	E		-									
49	Decimal Number Set															UC	E	E	UC			-								
50	Decimal Point															UC	E	E	E				-							
51	Letter Numbers															E	E	E	UC					-						
52	Byte Number Set					C																			-					
53	Word Number Set					C																				-				
54	Dword Number Set					C																					-			
55	Qword Number Set					C																						-		
56	Pi																												-	
57	2Pi																													-

Table 5.21: SCS Features Operational and Activation Dependencies (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
29	Inputs Display													U	U	U	U	UC					C			C				
30	Operations Results Display																	U								C				
31	Error messages Display									C									U	U						C				
32	Operations History Display																										C			
33	Binary Numbers Display																												C	
34	Statistics Data Display																UC	UC										C		
35	C																						C			C				
36	CE																						C			C				
37	Backspace																						C			C				
38	CAD																						C					C		
39	Error Clearing								Q	E																				
40	Memory Store																						C							
41	Memory Recall																						C							
42	Memory Clear																						C							
43	Decimal																	M				U		C						
44	Binary																	M				U		C						
45	Octane																	M				U		C						
46	Hexadecimal																	M				U		C						
47	Binary number set																	U					C							
48	Octane number Set																	U					C							
49	Decimal Number Set																	U					C							
50	Decimal Point																	U					C							
51	Letter Numbers																	U					C							
52	Byte Number Set	UC	E	E	E													U											C	
53	Word Number Set	E	UC	E	E													U											C	
54	Dword Number Set	E	E	UC	E													U											C	
55	Qword Number Set	E	E	E	UC													U											C	
56	Pi										E							U					C							
57	2Pi											QE						U					C							

Table 5.22: SCS Features Operational and Activation Dependencies (Cont…)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
58	Byte	U	U	U	U																								
59	Word	U	U	U	U																								
60	Dword	U	U	U	U																								
61	Qword	E	U	U	E																								
62	Degrees									U																			
63	Radians									U																			
64	Grads									U																			
65	Enable Calculator Functions																												
66	Disable Calculator Functions																												
67	Inverse-On		U															E	S		E	S						E	S
68	Inverse--Off		U															S	E		S	E						S	E
69	Equal	U	U	U	E																								
70	Sign	U	U	U	U																								
71	Arcs	E	U	U	E																								
72	Scientific Notation Editing	E	U	E	U							C																	
73	Add				U																								
74	Result Foundation	U	U	U	U										C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
75	Unexpected Input Handling																												
76	Error Notification	U	U	U	U																								
77	Parsing																												
78	Number Conversion																												
79	Calc Buttons														UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC
80	System Selection Buttons	E	E	U	E																								
81	Size Selection Buttons	E	E	U	E																								
82	Display Box																												
83	History Dialog Box			E	E									UC															
84	Statistics Dialog Box	E	E	E	U																								
85	Binary Numbers Dialog Box	E	E		E																								
86	Menu	U	U	U	U									U															

Table 5.23: SCS Features Operational and Activation Dependencies (Cont…)

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
58	Byte	M	M			M																			C	E	E	E		
59	Word	M	M			M																			E	C	E	E		
60	Dword	M	M			M																			E	E	C	E		
61	Qword	M	M			M																			E	E	E	C		
62	Degrees	M	M																											
63	Radians	M	M																											
64	Grads	M	M																											
65	Enable Calculator Functions											U																		
66	Disable Calculator Functions			UC								E																		
67	Inverse-On																												E	S
68	Inverse--Off																												S	E
69	Equal																													
70	Sign																													
71	Arcs																													
72	Scientific Notation Editing																													
73	Add						C																							
74	Result Foundation	C	Q				C																							
75	Unexpected Input Handling																													
76	Error Notification			Q																										
77	Parsing																													
78	Number Conversion																													
79	Calc Buttons	UC						UC	UC	UC	UC		UC	UC	UC					UC	UC	UC	UC	UC					UC	UC
80	System Selection Buttons															UC	UC	UC	UC											
81	Size Selection Buttons																													
82	Display Box	UC	UC	UC				UC	UC	UC																				
83	History Dialog Box				UC																									
84	Statistics Dialog Box						UC				UC																			
85	Binary Numbers Dialog Box					UC																			UC	UC	UC	UC		
86	Menu																													

Table 5.24: SCS Features Operational and Activation Dependencies (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
58	Byte	-	E	E	E													M							C					
59	Word	E	-	E	E													M							C					
60	Dword	E	E	-	E													M							C					
61	Qword	E	E	E	-													M							C					
62	Degrees					-	E	E										M					C							
63	Radians					E	-	E										M					C							
64	Grads					E	E	-										M					C							
65	Enable Calculator Functions								-											E										
66	Disable Calculator Functions									-																				
67	Inverse-On										-	E											C							
68	Inverse--Off										E	-											C							
69	Equal												-					Q					C							
70	Sign													-				U					C							
71	Arcs														-			U					C							
72	Scientific Notation Editing															-							C							
73	Add																-						C					C		
74	Result Foundation																	-		E	S	S								
75	Unexpected Input Handling																	U	-	Q										
76	Error Notification								E									ME		-										
77	Parsing																	U			-									
78	Number Conversion																	U				-								
79	Calc Buttons					UC	UC	UC			UC	UC	UC	UC	UC	UC	UC						-							
80	System Selection Buttons																													
81	Size Selection Buttons	UC	UC	UC	UC																									
82	Display Box																									-				
83	History Dialog Box																										-			
84	Statistics Dialog Box																UC											-		
85	Binary Numbers Dialog Box																												-	
86	Menu																													-

Table 5.25: SCS Features Operational and Activation Dependencies (Cont…)

Feature #	Features	Dependency Factors							Feature #	Features	Dependency Factors						
		Usage	Modification	Subordinate-Activation	Exclusive-Activation	Concurrent-Activation	Sequential-Activation	Total			Usage	Modification	Subordinate-Activation	Exclusive-Activation	Concurrent-Activation	Sequential-Activation	Total
1	Standard	0	1	20	38	0	0	59	44	Binary	2	3	0	10	2	0	17
2	Scientific	0	1	27	24	0	0	52	45	Octane	2	3	0	10	2	0	17
3	Programmer	0	0	19	26	0	0	45	46	Hexadecimal	2	3	0	9	3	0	17
4	Statistics	0	0	17	41	0	0	58	47	Binary No. Set	3	0	0	6	2	0	11
5	Display	4	0	10	0	0	0	14	48	Octane No. Set	3	0	0	6	2	0	11
6	Clearing	4	0	5	0	0	0	9	49	Decimal No. Set	7	0	0	2	3	0	12
7	Systems	5	0	10	0	0	0	15	50	Decimal Point	5	0	0	4	2	0	11
8	Size	5	0	9	0	0	0	14	51	Letter Numbers	3	0	0	6	2	0	11
9	Angle	2	0	3	3	0	0	8	52	Byte No. Set	3	0	0	6	3	0	12
10	Basic Notation	5	0	0	0	0	0	5	53	Word No. Set	3	0	0	6	3	0	12
11	Scientific Notation	4	0	0	1	1	0	6	54	Dword No. Set	3	0	0	6	3	0	12
12	Memory	4	0	3	0	0	0	7	55	Qword No. Set	3	0	0	6	3	0	12
13	History	2	0	0	2	1	0	5	56	Pi	2	0	0	4	1	0	7
14	Binary Operations	4	0	0	1	2	0	7	57	2Pi	2	0	0	4	1	1	8
15	Unique Operations	3	0	0	2	2	0	7	58	Byte	4	4	0	6	2	0	16
16	Exp Functions & Log	2	0	0	3	2	0	7	59	Word	4	4	0	6	2	0	16
17	Ln	2	0	0	4	2	0	8	60	Dword	4	4	0	6	2	0	16
18	e Function	2	0	0	4	2	1	9	61	Qword	2	4	0	8	2	0	16
19	n!	2	0	0	3	2	0	7	62	Degrees	1	3	0	2	1	0	7
20	SCTH Functions	2	0	0	4	2	0	8	63	Radians	1	3	0	2	1	0	7
21	SCTHI Functions	2	0	0	4	2	1	9	64	Grads	1	3	0	2	1	0	7
22	Basic Boolean Op.	2	0	0	3	2	0	7	65	Enable Calc Fun.	1	0	0	1	0	0	2
23	Extra Boolean Op.	2	0	0	3	2	0	7	66	Disable Calc Fun.	1	0	0	1	1	0	3
24	Statistics Operations	2	0	0	3	3	0	8	67	Inverse-On	1	0	4	5	1	0	11
25	Percentage (%)	2	0	0	3	2	0	7	68	Inverse--Off	1	0	4	5	1	0	11
26	Mod	3	0	0	2	2	0	7	69	Equal	3	0	0	1	1	1	6
27	Int & Dms	2	0	0	4	2	0	8	70	Sign	5	0	0	0	1	0	6
28	Frac & Deg	2	0	0	4	2	1	9	71	Arcs	3	0	0	2	1	0	6
29	Inputs display	32	0	0	3	3	0	38	72	Scientific Not. Editing	2	0	0	2	2	0	6
30	Op. Results Display	4	0	0	2	1	0	7	73	Add	1	0	0	0	3	0	4
31	Error messages Display	2	0	0	3	2	0	7	74	Result Foundation	4	0	2	1	17	1	25
32	History Display	3	0	0	2	1	0	6	75	Unexpected Input Handling	1	0	0	0	0	1	2
33	Binary No. Display	5	0	0	3	5	0	13	76	Error Notification	4	1	0	2	0	1	8
34	Statistics Data Display	4	0	0	4	4	0	12	77	Parsing	1	0	0	0	0	0	1
35	C	1	3	0	3	3	0	10	78	Number Conversion	1	0	0	0	0	0	1
36	CE	1	3	0	4	3	0	11	79	Calc Buttons	40	0	0	0	40	0	80
37	Backspace	1	1	0	1	2	0	5	80	System Selection Buttons	5	0	0	3	4	0	12
38	CAD	1	1	0	4	2	0	8	81	Size Selection Buttons	5	0	0	3	4	0	12
39	Error Clearing	2	0	0	2	2	1	7	82	Display Box	6	0	0	0	6	0	12
40	Memory Store	5	0	0	1	1	0	7	83	History Dialog Box	2	0	0	2	2	0	6
41	Memory Recall	4	0	0	0	1	0	5	84	Statistics Dialog Box	4	0	0	3	3	0	10
42	Memory Clear	4	1	0	1	1	0	7	85	Binary No. Dialog Box	5	0	0	3	5	0	13
43	Decimal	7	3	0	6	3	0	19	86	Menu	5	0	0	0	0	0	5

Table 5.26: SCS Features Dependencies Values

5.2.2 SCS Features Classification

In this section we present the classification results of *SCS* features. It contains two sub-sections: *SCS Dependencies Relations Weighting* and *SCS Features Classification Process*. Each sub-section will present and discuss the *Classification Phase* step results. The outcome of this section will be *SCS Features Sets*.

- **SCS dependencies Relations Weighting**

  As we do for the previous case study before starting weighting process we have to adjust the information shown in *Table 5.17*; to *Table 5.25*. The *Adjustment Process* results are shown in *Appendix B at Table B.3; to Table B.10*. We use those results with the results of dependencies values after *Adjustment Processes* shown in *Appendix B* at *Table B.11*; to implement the weighting process.

  As presented in *Chapter 3*, the *Weighting Procedure* is applied for each *SCS* features relation. For more details about weighting process and its results see *Appendix B*. *Table 5.27*; to *Table 5.32*; show the *SCS* features dependencies weights that used as input data for *Pajek* to implement the *Classification Process*.

- SCS Features Classification Process

  After we get the features relations weights we transform these data to a text file (*the content of the text file can be seen in Appendix B*). Then, we used *Pajek* tool as discussed in *Chapter 3*, to classify *SCS* features into number of Features Sets. *Table 5.33*; shows the clustering errors and numbers of solutions results of SCS features using *Pajek*.

As shown in *Table 5.33*; we start the clustering process with *Number of Clusters = 86*, which means each feature will be in a separated cluster, and repeat the *Classification Process 86* times until *Number of Clusters = 1, which means* all SCS features be in one cluster. More details about clustering results appear at *Appendix B in Table B.12; Table B.13; and Table B.14.*

As discussed in *Chapter 3*, we select the classification results based on the *Minimum Clustering Error* (and *Minimum Number of Possible Solutions*). Form the results shown in *Table 5.33;* we notice that we have *12* clustering results share the same value of *Minimum Clustering Error = 71*, and form these results the one which has the *Minimum Number of Possible Solutions = 1*, is the result clustering when number of clusters = *27*; (*as discussed before there might be numbers of solutions for one clustering process, so that we choose the closest clustering result to the optimum solution*). From this result we identify the *SCS Features Sets* as shown in *Table 5.34*; in which we notice that the fourth *Features Set* contains *2* features (*Statistics Calc* and *Add*) and the fifth *Features Set* contains *12* features (*Display Service, Input Display, Operations Results Display, Error messages Display, Operations History Display, Binary Numbers Display, Statistics Data Display, Disable Calculator Functions, Display Box , History Dialog Box, Statistics Dialog Box, and Binary Numbers Dialog Box*) and so on for the remaining Features Sets. More details about the *Classification Process* results from *Pajek* are presented in *Appendix B.*

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
1	Standard	-	-4	-4	-4	-8	-8	-8	-8	-4	-8	-8	-8	-8	-8	-8	-4	-4	-4	-4	-4	-4	-4	-4	-4	-2	-4	-4	-4
2	Scientific	-	-	-4	-4	-8	-8	-8	-8	-2	-8	-8	-8	-8	-8	-8	-2	-5	-5	-2	-5	-5	-4	-4	-4	-4	-8	-5	-5
3	Programmer	-	-	-	-4	-8	-8	-8	-8	-4	-8	-4	-8	-4	-8	-4	-4	-4	-4	-4	-4	-4	-2	-2	-4	-4	-8	-4	-4
4	Statistics	-	-	-	-	-8	-8	-8	-8	-4	-8	-8	-8	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-2	-4	-4	-4	-4
5	Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Clearing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Angle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Basic Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Scientific Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Memory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	History	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Binary Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Unique Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Exp Functions & Log	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Ln	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	e Function	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	n!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	SCTH Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	SCTHI Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Basic Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Extra Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Statistics Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Percentage (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Mod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	Int & Dms	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	Frac & Deg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.27: SCS features Dependencies Weights for Pajek

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
1	Standard	-	-	-	-7	-4	-4	-	-	-	-4	-	-5	-5	-5	-5	-4	-4	-4	-4	-4	-5	-5	-4	-4	-4	-4	-4	-4	-4
2	Scientific	-	-	-	-7	-4	-4	-	-	-	-4	-	-5	-5	-5	-5	-4	-4	-4	-4	-4	-5	-5	-4	-4	-4	-4	-4	-5	-5
3	Programmer	-	-	-	-4	-5	-4	-	-	-	-4	-	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-4	-5	-5	-5	-5	-5	-4	-4
4	Statistics	-	-	-	-4	-4	-5	-	-4	-	-	-	-5	-5	-5	-5	-4	-4	-4	-4	-4	-5	-5	-4	-4	-4	-4	-4	-4	-4
5	Display	3	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Clearing	-	-	-	-	-	-	8	8	8	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	3	3	3	3	3	-	-	-	-	-	-
8	Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	-	-
9	Angle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Basic Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Scientific Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Memory	-	-	-	-	-	-	-	-	-	-	-	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	History	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Binary Operations	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Unique Operations	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Exp Functions & Log	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Ln	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	e Function	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	n!	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	SCTH Functions	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	SCTHI Functions	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Basic Boolean Operation	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Extra Boolean Operation	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Statistics Operations	-	-	-	-	-	-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Percentage (%)	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Mod	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	Int & Dms	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	Frac & Deg	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.28: SCS features Dependencies Weights for Pajek (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
1	Standard	-5	-5	-5	-4	-	-	-	-3	-3	-	-	-8	-8	-4	-4	-	-8	-3	-8	-	-	-3	-4	-4	-	-	-4	-4	-8
2	Scientific	-5	-5	-5	-5	-	-	-	-3	-3	8	8	-8	-8	-8	-8	-	-8	-3	-8	-	-	-3	-4	-4	-	-	-4	-4	-8
3	Programmer	-5	-5	-5	-5	-	-	-	-3	-3	-	-	-8	-8	-8	-4	-	-8	-	-8	-	-	-3	-5	-5	-	-4	-4	-	-8
4	Statistics	-5	-5	-5	-4	-	-	-	-3	-3	-	-	-4	-8	-4	-8	8	-8	-	-8	-	-	-3	-4	-4	-	-4	-5	-4	-8
5	Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	-
6	Clearing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	3	-	-	-	-	-	-
8	Size	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	3	-	-	-	-	-
9	Angle	-	-	-	-	8	8	8	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-	-
10	Basic Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-	-
11	Scientific Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-	-5	-	-	-	-	-	-	-	-	-	-	-	-
12	Memory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	History	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-5
14	Binary Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
15	Unique Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
16	Exp Functions & Log	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
17	Ln	-	-	-	-	-	-	-	-	-	-4	3	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
18	e Function	-	-	-	-	-	-	-	-	-	3	-5	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
19	n!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
20	SCTH Functions	-	-	-	-	-	-	-	-	-	-4	3	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
21	SCTHI Functions	-	-	-	-	-	-	-	-	-	3	-5	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
22	Basic Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
23	Extra Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
24	Statistics Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
25	Percentage (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
26	Mod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
27	Int & Dms	-	-	-	-	-	-	-	-	-	-4	3	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-
28	Frac & Deg	-	-	-	-	-	-	-	-	-	3	-5	-	-	-	-	-	-9	-	-	-	-	-9	-	-	-	-	-	-	-

Table 5.29: SCS features Dependencies Weights for Pajek (Cont…)

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
29	Inputs Display	-	-	-	-5	-	-	-6	-6	-6	-	-	-5	-	-	-2	-2	-2	-2	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
30	Operations Results Display	-	-	-	-5	-	-	-6	-6	-	-	-	-	-5	-5	-2	-2	-2	-2	-	-	-	-	-	-	-	-	-	-	-
31	Error messages Display	-	-	-	-	-	-	-6	-6	-	-	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Operations History Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	Binary Numbers Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-9	-9	-9	-	-
34	Statistics Data Display	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	C	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	CE	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	Backspace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	CAD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	Error Clearing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Memory Store	-	-	-	-	-	-	-	-	-	-	-	-	-5	-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Memory Recall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	Memory Clear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	Decimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-4	-4	-4	-4	-9	-9	-4	-	-	-	-	-	-
44	Binary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-4	-9	-4	-4	-4	-4	-	-	-	-	-	-
45	Octane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-4	-9	-4	-4	-4	-	-	-	-	-	-
46	Hexadecimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-4	-9	-4	-9	-	-	-	-	-	-
47	Binary number set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	Octane number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	Decimal Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	Decimal Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	Letter Numbers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	Byte Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	Word Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	Dword Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	Qword Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	Pi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	2Pi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.30: SCS features Dependencies Weights for Pajek (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
29	Inputs Display	-2	-2	-2	-2	-2	-2	-2	-	-	-	-	-	-5	-5	-5	-5	-9	-	-	-	-	-9	-	-	-9	-	-	-	-
30	Operations Results Display	-2	-2	-2	-2	-2	-2	-2	-	-	-	-	-	-	-	-	-	-4	-	-	-	-	-	-	-	-9	-	-	-	-
31	Error messages Display	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-5	-4	-	-	-	-	-	-9	-	-	-	-
32	Operations History Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-
33	Binary Numbers Display	-2	-2	-2	-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-
34	Statistics Data Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-9	-	-	-	-	-	-	-	-	-	-9	-	-
35	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-9	-	-	-	-
36	CE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-9	-	-	-	-
37	Backspace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-9	-	-	-	-
38	CAD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-
39	Error Clearing	-	-	-	-	-	-	-	6	-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Memory Store	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
41	Memory Recall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
42	Memory Clear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
43	Decimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-5	-	-9	-	-	-	-	-	-
44	Binary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-5	-	-9	-	-	-	-	-	-
45	Octane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-5	-	-9	-	-	-	-	-	-
46	Hexadecimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-5	-	-9	-	-	-	-	-	-
47	Binary number set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
48	Octane number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
49	Decimal Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
50	Decimal Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
51	Letter Numbers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
52	Byte Number Set	-9	-4	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-9	-
53	Word Number Set	-4	-9	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-9	-
54	Dword Number Set	-4	-4	-9	-4	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-9	-
55	Qword Number Set	-4	-4	-4	-9	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-	-	-	-	-	-	-9	-
56	Pi	-	-	-	-	-	-	-	-	-	-4	3	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
57	2Pi	-	-	-	-	-	-	-	-	-	3	-5	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-

Table 5.31: SCS features Dependencies Weights for Pajek (Cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
58	Byte	-	-4	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-	-	-9	-	-	-	-	-
59	Word	-	-	-4	-4	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-	-	-9	-	-	-	-	-
60	Dword	-	-	-	-4	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-	-	-9	-	-	-	-	-
61	Qword	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-	-	-9	-	-	-	-	-
62	Degrees	-	-	-	-	-	-4	-4	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-9	-	-	-	-	-	-	-
63	Radians	-	-	-	-	-	-	-4	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-9	-	-	-	-	-	-	-
64	Grads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2	-	-	-	-	-9	-	-	-	-	-	-	-
65	Enable Calculator Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4	-	-	-	-	-	-	-	-	-	-
66	Disable Calculator Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Inverse-On	-	-	-	-	-	-	-	-	-	-	-4	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
68	Inverse--Off	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
69	Equal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-9	-	-	-	-	-	-	-
70	Sign	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
71	Arcs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-	-	-	-9	-	-	-	-	-	-	-
72	Scientific Notation Editing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-	-	-
73	Add	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9	-	-	-	-	-9	-	-
74	Result Foundation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-6	8	8	-	-	-	-	-	-	-	-
75	Unexpected Input Handling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
76	Error Notification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	Parsing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78	Number Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	Calc Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80	System Selection Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	Size Selection Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Display Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	History Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84	Statistics Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85	Binary Numbers Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86	Menu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.32: SCS features Dependencies Weights for Pajek (Cont…)

Number of clusters	*Error of clustering*	*Number of solution found*	*Number of clusters*	*Error of clustering*	*Number of solution found*
1	2889	1	44	81	463
2	597	4	45	85	1103
3	238	4	46	85	1
4	142	2108	47	88	1846
5	118	1	48	90	1
6	101	1	49	88	1
7	93	633	50	91	684
8	84	1	51	96	1
9	81	303	52	97	1
10	75	1	53	97	1
11	78	1	54	100	1
12	78	630	55	102	1
13	75	1	56	105	1
14	77	1	57	106	1
15	75	902	58	110	1
16	73	1	59	108	1
17	73	1	60	118	1
18	71	486	61	114	1
19	71	1086	62	122	133
20	71	2064	63	121	1
21	71	1230	64	125	133
22	71	688	65	131	1
23	71	2621	66	136	1
24	71	671	67	138	149
25	71	2069	68	140	1
26	71	1513	69	147	1
27	71	1	70	149	1
28	71	2143	71	154	1
29	71	1430	72	156	1
30	74	5175	73	164	1
31	74	2844	74	167	1
32	74	2083	75	176	128
33	74	3205	76	179	77
34	74	779	77	183	1
35	74	1	78	188	297
36	74	1	79	193	17
37	75	1	80	197	1
38	75	1	81	204	20
39	78	3048	82	212	18
40	78	1	83	220	24
41	81	1805	84	228	12
42	81	606	85	236	1
43	78	1	86	245	1

Table 5.33: Pajek's Clustering Errors and numbers of solutions for SCS Features

Feature #	Features	*Features Set #*	Feature #	Features	*Features Set #*
1	Standard	1	9	Angle	9
2	Scientific	2	62	Degrees	
3	Programmer	3	63	Radians	
4	Statistics	4	64	Grads	
73	Add		10	Basic Notation	10
5	Display	5	11	Scientific Notation	11
29	Inputs display		72	Scientific Notation Editing	
30	Operations Results Display		12	Memory	12
31	Error messages Display		40	Memory Store	
32	Operations History Display		41	Memory Recall	
33	Binary Numbers Display		42	Memory Clear	
34	Statistics Data Display		13	History	13
66	Disable Calculator Functions		14	Binary Operations	14
82	Display Box		15	Unique Operations	15
83	History Dialog Box		16	Exp Functions & Log	16
84	Statistics Dialog Box		19	n!	
85	Binary Numbers Dialog Box		68	Inverse-Off	17
6	Clearing	6	17	Ln	
35	C		20	SCTH Functions	
36	CE		27	Int & Dms	
37	Backspace		56	Pi	
38	CAD		67	Inverse-On	18
39	Error Clearing		18	e Function	
65	Enable Calculator Functions		21	SCTHI Functions	
7	Systems	7	28	Frac & Deg	
43	Decimal		57	2 Pi	
44	Binary		22	Basic Boolean Operation	19
45	Octane		23	Extra Boolean Operation	
46	Hexadecimal		24	Statistics Operations	20
47	Binary number set		25	Percentage (%)	21
48	Octane number Set		26	Mod	22
49	Decimal Number Set		70	Sign	23
50	Decimal Point		71	Arcs	24
51	Letter Numbers		69	Equal	25
80	Systems Selection Buttons		74	Result Foundation	
8	Size	8	75	Unexpected Input Handling	
52	Byte Number Set		76	Error Notification	
53	Word Number Set		77	Parsing	
54	Dword Number Set		78	Number Conversion	
55	Qword Number Set		79	Calc Buttons	26
58	Byte		86	Menu	27
59	Word				
60	Dword				
61	Qword				
81	Size Selection Buttons				

Table 5.34: SCS Features Sets

5.2.3 SCS Features Sets Reuse Opportunity Computing

In this section we compute the *SCS Features Sets Reuse Opportunity*. As presented in *Chapter 3*, there are three factors for feature *Reuse Opportunity*: *Feature Model Factor (FMF), MPP Factor (MPPF),* and *Dependency factor (DF).* We compute *Features Set Reuse Opportunity* for *SCS Features Sets* as illustrated for the previous case study. The results of these computations are presented in *Appendix B*. The following sub-sections present and discuss the computation process of *SCS Features Sets Reuse Opportunity*.

- **Computing SCS Features Sets Feature Model Factor (FSFMF)**

  Before computing *FSFMF* we need to compute *FMF* for each *SCS* feature. These computations will be based on *Chapter 3*, equations (10) to (14). *Table B.15*; *Table B.16*; and *Table B.17*; show the results of these computations.

  Table 5.35; shows the results of *SCS Features Sets FSFMF*. From these results it be noticed that *FSFMF* value is based on the number of features within the *Features Set* and those features types.

- **Computing SCS Features Sets MPP Factor (FSMPPF)**

  To compute *FSMPPF* we first compute features *MPPF* based on information within *Table B.1*; *Table B.2*; and chapter 3 equations (15) to (19). *Table B.15*; *Table B.16*; *Table B.17*; show SCS features *MPPF* results. From these results it can be seen that some *MPP* attributes and then their *MPP* sub-factor results related to feature type.

  Then form those results we compute *FSMPPF* for each *SCS Features Set* based on *Chapter 3* equations (20) to (24). *Table 5.36*; presents the *SCS Features Sets FSMPPF* values.

- **Computing SCS Features Sets Dependency Factor (FSDF)**

  SCS features dependencies values was computes through the *Classification Process* based on *Chapter 3* equations (25), (26), and (27). Here we compute dependencies factors (*DF*) and internal dependencies factors (*IDF*) for each *Features Set* in *SCS*. *Table B.15*; *Table B.16*; *Table B.17*; show *SCS* features *DF* and *IDF* results. And the results of computing *FSDF* for *SCS Features Sets* are shown in *Table 5.37*. These computations also based on the previous equations (25), (26), and (27) in *Chapter 3*. As these results shown the value of each one of *DF*, *IDF*, and *FSDF* is based on the number of *Features Set's* features and these features' relations number.

- **Computing SCS Features Sets Reuse Opportunity (FSRO)**

  Finally, we can use the equation (28) in *Chapter 3*; to compute *SCS Features Sets Reuse Opportunity* (*FSRO*). *Table 5.38*; shows the computations results of *SCS Features Sets FSRO*.

Features Set #	***Features Set Name***	***FSFMF***
1	Standard	1
2	Scientific	0.5
3	Programmer	0.5
4	Statistics	0.5
5	Display	0.58333333
6	Clearing	0.71428571
7	Systems	0.52272727
8	Size	0.4
9	Angle	0.3125
10	Basic Notation	0.5
11	Scientific Notation	0.375
12	Memory	0.5
13	History	0.5
14	Binary Operations	1
15	Unique Operations	0.5
16	Exp Functions	0.375
17	Inverse-Off	0.3
18	Inverse-On	0.275
19	Boolean Operations	0.375
20	Statistics Operations	0.5
21	Percentage (%)	0.5
22	Mod	0.5
23	Sign	1
24	Arcs	0.5
25	Result Foundation	0.75
26	Calc Buttons	1
27	Menu	0.5
System		0.51889535

Table 5.35: FSFMF of Features Sets in SCS

Features Set #	*Features Set Name*	*Features Sets MPP Factors*				*FSMPPF*
		FSNA	*FSPR*	*FSFC*	*FSBT*	
1	Standard	1	0.0105354	1	1	0.75263384
2	Scientific	0.63	0.0184906	0.89	0.5	0.50962266
3	Programmer	0.57	0.0047302	0.44	0.5	0.37868254
4	Statistics	0.695	0.0127929	0.885	0.75	0.58569824
5	Display	0.64	0.0129542	0.7175	0.6666667	0.50928022
6	Clearing	0.79714286	0.0147741	0.8571429	0.7857143	0.61369352
7	Systems	0.63272727	0.0097926	0.6227273	0.6363636	0.47540270
8	Size	0.415	0.0117609	0.831	0.75	0.50194023
9	Angle	0.28	0.0054827	0.885	0.625	0.44887067
10	Basic Notation	0.61	0.0129005	1	1	0.65572511
11	Scientific Notation	0.295	0.0176306	0.755	0.5	0.39190765
12	Memory	0.63	0.0147818	0.8825	0.875	0.60057044
13	History	0.6	0.0027951	0.49	0.5	0.39819877
14	Binary Operations	1	0.0086003	1	1	0.75215008
15	Unique Operations	0.75	0.0178456	0.17	0.5	0.35946141
16	Exp Functions	0.415	0.0167706	0.63	0.75	0.45294265
17	Inverse-Off	0.208	0.0137175	0.882	0.8	0.47592937
18	Inverse-On	0.176	0.0067082	0.302	0.5	0.24617706
19	Boolean Operations	0.585	0.0127929	0.855	0.75	0.55069824
20	Statistics Operations	0.73	0.0081703	0.1	0.5	0.33454257
21	Percentage (%)	0.5	0.0090303	1	1	0.62725758
22	Mod	0.69	0.0122554	1	1	0.67556386
23	Sign	1	0.0090303	1	1	0.75225758
24	Arcs	0.58	0.0043002	0.7	0.5	0.44607504
25	Result Foundation	0.81333333	0.0119688	0.9916667	0.9166667	0.68340885
26	Calc Buttons	1	0.0161256	1	1	0.75403139
27	Menu	0.53	0.0060202	0.78	0.5	0.45400505
System		0.569535	0.011628	0.761977	0.720930	0.51601744

Table 5.36: SCS Features Sets MPP Factors Values and FSMPPF Values

Features Set #	*Features Set Name*	*DF*	*IDF*	*FSDF*
1	Standard	0.6941176	0	0.1156863
2	Scientific	0.6117647	0	0.1019608
3	Programmer	0.5294118	0	0.0882353
4	Statistics	0.7294118	0.0238095	0.1176004
5	Display	1.6588235	0.4459459	0.2021463
6	Clearing	0.6117647	0.2151899	0.0660958
7	Systems	1.8	1.0533333	0.1244444
8	Size	1.6235294	0.9078947	0.1192724
9	Angle	0.3411765	0.1463415	0.0324725
10	Basic Notation	0.0588235	0	0.0098039
11	Scientific Notation	0.1411765	0.0238095	0.0195612
12	Memory	0.3058824	0.0731707	0.0387853
13	History	0.0588235	0	0.0098039
14	Binary Operations	0.0823529	0	0.0137255
15	Unique Operations	0.0823529	0	0.0137255
16	Exp Functions	0.1647059	0	0.027451
17	Inverse-Off	0.4941176	0.0493827	0.0741225
18	Inverse-On	0.5411765	0.0493827	0.0819656
19	Boolean Operations	0.1647059	0	0.027451
20	Statistics Operations	0.0941176	0	0.0156863
21	Percentage (%)	0.0823529	0	0.0137255
22	Mod	0.0823529	0	0.0137255
23	Sign	0.0705882	0	0.0117647
24	Arcs	0.0705882	0	0.0117647
25	Result Foundation	0.5058824	0.125	0.0634804
26	Calc Buttons	0.9411765	0	0.1568627
27	Menu	0.0588235	0	0.0098039
System		12.129412	12.129412	0

Table 5.37: Features Sets Dependencies Factors (FSDF) in SCS

Features Set #	*Features Set Name*	*Reuse Opportunity Factors*			*FSRO*
		FSFMF	*FSMPPF*	*FSDF*	
1	Standard	1	0.75263384	0.11568627	1.86832012
2	Scientific	0.5	0.50962266	0.10196078	1.11158345
3	Programmer	0.5	0.37868254	0.08823529	0.96691784
4	Statistics	0.5	0.58569824	0.11760037	1.20329861
5	Display	0.58333333	0.50928022	0.20214626	1.29475981
6	Clearing	0.71428571	0.61369352	0.06609581	1.39407504
7	Systems	0.52272727	0.47540270	0.12444444	1.12257442
8	Size	0.4	0.50194023	0.11927245	1.02121267
9	Angle	0.3125	0.44887067	0.03247250	0.79384317
10	Basic Notation	0.5	0.65572511	0.00980392	1.16552903
11	Scientific Notation	0.375	0.39190765	0.01956116	0.78646881
12	Memory	0.5	0.60057044	0.03878527	1.13935571
13	History	0.5	0.39819877	0.00980392	0.90800270
14	Binary Operations	1	0.75215008	0.01372549	1.76587557
15	Unique Operations	0.5	0.35946141	0.01372549	0.87318690
16	Exp Functions	0.375	0.45294265	0.02745098	0.85539363
17	Inverse-Off	0.3	0.47592937	0.07412249	0.85005186
18	Inverse-On	0.275	0.24617706	0.08196563	0.60314268
19	Boolean Operations	0.375	0.55069824	0.02745098	0.95314922
20	Statistics Operations	0.5	0.33454257	0.01568627	0.85022885
21	Percentage (%)	0.5	0.62725758	0.01372549	1.14098307
22	Mod	0.5	0.67556386	0.01372549	1.18928935
23	Sign	1	0.75225758	0.01176471	1.76402228
24	Arcs	0.5	0.44607504	0.01176471	0.95783974
25	Result Foundation	0.75	0.68340885	0.06348039	1.49688925
26	Calc Buttons	1	0.75403139	0.15686275	1.91089414
27	Menu	0.5	0.45400505	0.00980392	0.96380897
System[17]		0.51889535	0.51601744	0	1.03491279

Table 5.38: FSRO of Features Sets in SCS

[17] *We count the whole system as a Features Set contains all system features.*

5.2.4 SCS Features Sets Options Analysis

In this phase we use *ROT* concepts to prioritize *SCS Features Sets* for the system core asset development. The *Black-Scholes* and *Chooser Option* formulas used to value the *Features Sets* as options. As discussed in *Chapter 3*, this phase includes two steps: *Reuse Opportunity Valuation* and *Features Sets Development Priority*. The coming sub-sections show these steps results and the results discussions.

- **SCS Features Sets Reuse Opportunities Valuations**

  To calculate *Features Sets Pricing* we use *Chapter 3's* equations, i.e. equation (28) for *Call Option Pacing*, equation (29) for *Put Option Pricing*, and equation (30) for *Chooser Option Pricing*. These equations are computed for each *SCS Features Set Reuse Opportunity* which is counted as an option. We start these calculations by equations' parameters initialization as shown below:

  $S = FSRO\ (A_i)$, (*Reuse Opportunity* value of SCS's *Features Set* A_i, $i = 1$ *to* N, $N = 27$, *Number of SCS Features Sets*).

  X[18] $= FSRO(System) = 1.03491279$, (*Reuse Opportunity* value of *SCS* system).

  $r = 1\%$

  $\sigma = 25\%$

  $T = N - 1 = 27 - 1 = 26$, (*Available remaining iterations after the development of the Features Set A*).

  $T_2 = T = 26$.

  $t_1 = 1$, *(i.e. each Features Set will be developed at one iteration).*

[18] *We also compute option prices for SCS Features Sets without using the system Reuse Opportunity, i.e. X = S = FSRO(Features Set). The results and discussions of these computations are shown in Appendix B.*

Using *S = FSRO(Features Set)* and *X = FSRO(whole system)* means that the choice is between features Set development and whole system development at the current development iteration with respect to other equation's parameters.

After the initialization process we calculate the results of each option. *Table 5.39*; shows the results of *SCS Features Sets Options Prices*.

Form the results shown in *Table 5.39*; we notice that *Call Option Price* (*i.e. choice of develop*) of any *Features Set* is *larger* than its *Put Option Price* (*i.e. choice of postpone*), when its *Reuse Opportunity* is *larger* than (*or equal to*) the *Reuse Opportunity* of the whole system. Also, we can notice that the *Chooser Option Price* of any *Features Set* is follow its *largest* value of its *Call* or *Put Price*, which gives an indication to the best choice that should be *Call* or *Put* for any *Features Set*.

- **SCS Features Sets Development Priorities**

In this step we put the results of *SCS Features Sets Options Valuations* in the order based on their values starting from the *largest* to the *smallest*. This order shows the *Development Priority* of each *SCS Features Set*.

In addition to the previous notes, it is clear from the results shown in *Table 5.39*; that *Features Set* that has the *largest Call Option Price*, also has the *smallest Put Option Price*. This means it has the *largest* priority to be developed at the *earliest* development iterations and the *smallest* priority to be postponed to *latest* development iterations.

Table 5.40; shows the *SCS Features Sets Development Priorities*. And *Figure 5.11*; shows the relation between *Reuse Opportunities, Call Option Prices, Put Option Prices,* and *Chooser Option Prices* of *SCS Features Sets*.

We also, calculate the options prices of each *SCS* feature (i.e. without classification into *Features Sets*). The computation results are shown in *Table 5.41*; and *Table 5.42*. It is clear that what we said about *SCS Features Sets Options Analysis* is also, true when we use *features* instead of *Features Sets*. *Figure 5.12*; and *Figure 5.13*; show the *SCS* features options analysis.

In addition to the previous computations, we compute option prices for SCS features and SCS Features Sets without using the system Reuse Opportunity, i.e. S = X = FSOR(Features Set), (or S = X = FRO(Feature) when the computations are for features). The results and discussions of these computations are shown in Appendix B.

Features Set #	*Features*	*Option Pricing Parameters*				*Option Price*		
		FSRO	*r*	*σ*	*T*	*Call*	*Put*	*Option Value*
1	Standard	1.86832012	1%	25%	26	0.99615677	0.48110929	0.99647313
2	Scientific	1.11158345				0.42857053	0.67025972	0.50246313
3	Programmer	0.96691784				0.33482171	0.72117651	0.50701696
4	Statistics	1.20329861				0.49112300	0.64109703	0.53205534
5	Display	1.29475981				0.55560041	0.61411323	0.57761488
6	Clearing	1.39407504				0.62773428	0.58693188	0.63866270
7	Systems	1.12257442				0.43594751	0.66664573	0.50492315
8	Size	1.02121267				0.36924443	0.70130439	0.49639936
9	Angle	0.79384317				0.23216614	0.79159560	0.62324549
10	Basic Notation	1.16552903				0.46509420	0.65283780	0.51752180
11	Scientific Notation	0.78646881				0.22805923	0.79486305	0.63073287
12	Memory	1.13935571				0.44727517	0.66119209	0.50930066
13	History	0.90800270				0.29860457	0.74387451	0.53249070
14	Binary Operations	1.76587557				0.91373479	0.50113186	0.91442466
15	Unique Operations	0.87318690				0.27779639	0.75788213	0.55461369
16	Exp Functions	0.85539363				0.26734158	0.76522059	0.56790155
17	Inverse-Off	0.85005186				0.26422728	0.76744806	0.57214324
18	Inverse-On	0.60314268				0.13437096	0.88450091	0.83667831
19	Boolean Operations	0.95314922				0.32624862	0.72637204	0.51163211
20	Statistics Operations	0.85022885				0.26433028	0.76737407	0.57200087
21	Percentage (%)	1.14098307				0.44837774	0.66066731	0.50976357
22	Mod	1.18928935				0.48142604	0.64540933	0.52632314
23	Sign	1.76402228				0.91225638	0.50150673	0.91295603
24	Arcs	0.95783974				0.32916189	0.72459479	0.50996955
25	Result Foundation	1.49688925				0.70448679	0.56087018	0.70966558
26	Calc Buttons	1.91089414				1.03079526	0.47317376	1.03102390
27	Menu	0.96380897				0.33288030	0.72234396	0.50798891
	System	1.03491279						

Table 5.39: Options Prices of SCS's Features Sets

Features Set #	*Features Set Name*	*Options ROFS*	*Option Price*			*Development Priority*
			Call	**Put**	**Option Value**	
26	Calc Buttons	1.91089414	1.03079526	0.47317376	1.03102390	1st
1	Standard	1.868320117	0.996156773	0.481109294	0.996473134	2nd
14	Binary Operations	1.765875565	0.91373479	0.50113186	0.91442466	3rd
23	Sign	1.76402228	0.91225638	0.50150673	0.91295603	4th
25	Result Foundation	1.49688925	0.70448679	0.56087018	0.70966558	5th
6	Clearing	1.394075042	0.62773428	0.58693188	0.63866270	6th
5	Display	1.294759815	0.55560041	0.61411323	0.57761488	7th
4	Statistics	1.20329861	0.49112300	0.64109703	0.53205534	8th
22	Mod	1.18928935	0.48142604	0.64540933	0.52632314	9th
10	Basic Notation	1.165529034	0.46509420	0.65283780	0.51752180	10th
21	Percentage (%)	1.14098307	0.44837774	0.66066731	0.50976357	11th
12	Memory	1.139355712	0.44727517	0.66119209	0.50930066	12th
7	Systems	1.122574416	0.43594751	0.66664573	0.50492315	13th
2	Scientific	1.111583446	0.42857053	0.67025972	0.50246313	14th
8	Size	1.021212674	0.36924443	0.70130439	0.49639936	15th
3	Programmer	0.966917836	0.33482171	0.72117651	0.50701696	16th
27	Menu	0.96380897	0.33288030	0.72234396	0.50798891	17th
24	Arcs	0.95783974	0.32916189	0.72459479	0.50996955	18th
19	Boolean Operations	0.95314922	0.32624862	0.72637204	0.51163211	19th
13	History	0.908002696	0.29860457	0.74387451	0.53249070	20th
15	Unique Operations	0.873186896	0.27779639	0.75788213	0.55461369	21st
16	Exp Functions	0.855393627	0.26734158	0.76522059	0.56790155	22nd
20	Statistics Operations	0.85022885	0.26433028	0.76737407	0.57200087	23rd
17	Inverse-Off	0.85005186	0.26422728	0.76744806	0.57214324	24th
9	Angle	0.793843174	0.23216614	0.79159560	0.62324549	25th
11	Scientific Notation	0.786468812	0.22805923	0.79486305	0.63073287	26th
18	Inverse-On	0.60314268	0.13437096	0.88450091	0.83667831	27th

Table 5.40: Development Priority of SCS Features Sets

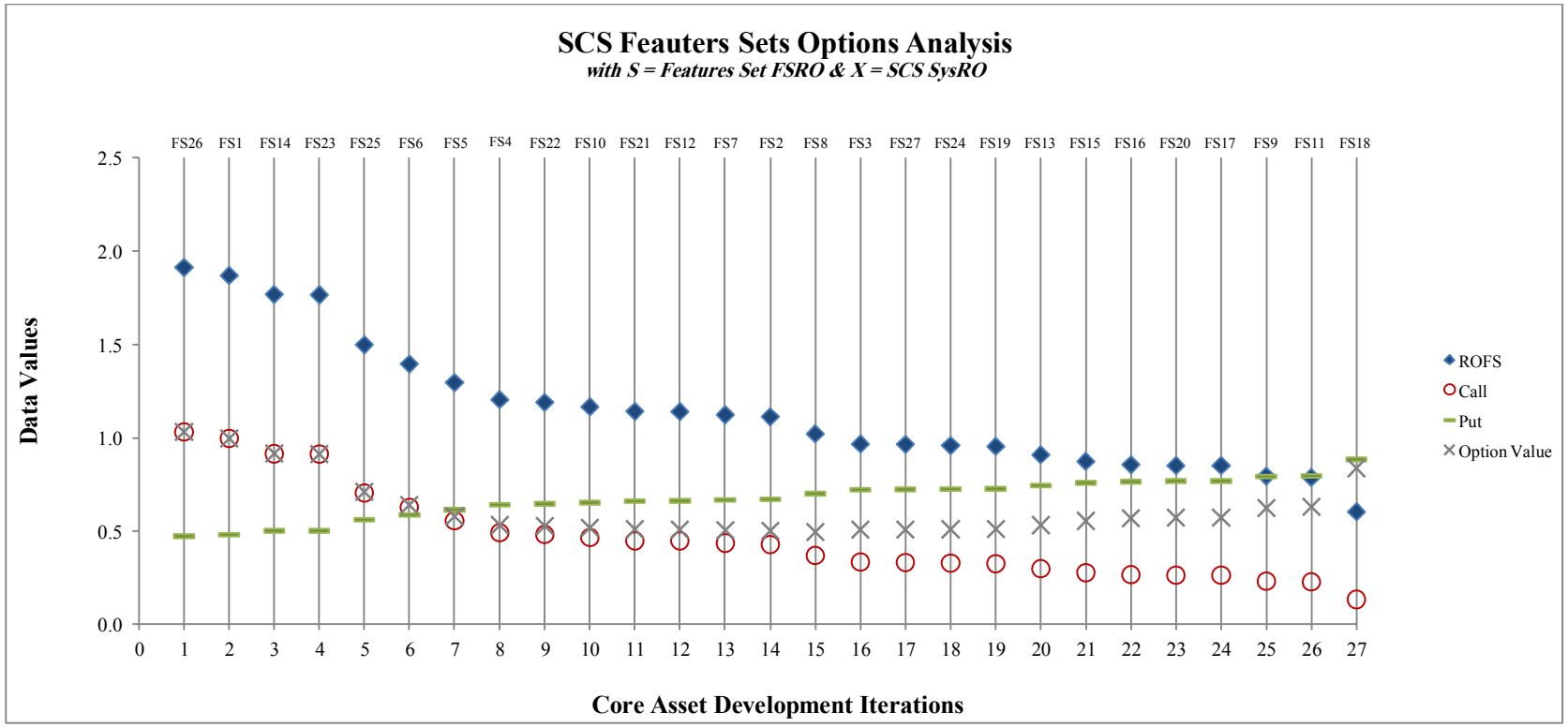

Figure 5.11: SCS Features Sets Options Analysis

Feature #	Features	Options	Option Price			Development Priority
		ROFS	Call	Put	Option Value	
79	Calc Buttons	2.6952079	2.356771	0.411719	2.356771	1st
1	Standard	2.4467515	2.119973	0.423378	2.119973	2nd
29	Inputs Display	2.2010365	1.886914	0.436033	1.886914	3rd
74	Result Foundation	2.0479878	1.742411	0.444579	1.742411	4th
5	Display	1.9182535	1.620379	0.452282	1.620379	5th
82	Display Box	1.8945091	1.598094	0.453741	1.598094	6th
49	Decimal Number Set	1.8923053	1.596027	0.453877	1.596027	7th
50	Decimal Point	1.8836582	1.587916	0.454413	1.587916	8th
35	C	1.8728072	1.57774	0.455089	1.57774	9th
6	Clearing	1.858785	1.564596	0.455967	1.564596	10th
76	Error Notification	1.8491166	1.555537	0.456576	1.555537	11th
39	Error Clearing	1.8365456	1.543762	0.457372	1.543762	12th
30	Operations Results Display	1.8348793	1.542201	0.457478	1.542201	13th
14	Binary Operations	1.834503	1.541849	0.457502	1.541849	14th
70	Sign	1.8228458	1.530935	0.458245	1.530935	15th
69	Equal	1.8211258	1.529325	0.458355	1.529325	16th
4	Statistics	1.6891531	1.406073	0.467075	1.406073	17th
2	Scientific	1.6213874	1.343015	0.471784	1.343015	18th
3	Programmer	1.4080943	1.145716	0.487778	1.145718	19th
59	Word	1.3577241	1.099417	0.491849	1.099419	20th
43	Decimal	1.3511633	1.093395	0.492388	1.093398	21st
8	Size	1.3312373	1.075121	0.494039	1.075124	22nd
58	Byte	1.3188529	1.063773	0.495076	1.063777	23rd
52	Byte Number Set	1.2919827	1.03918	0.497353	1.039185	24th
53	Word Number Set	1.2874391	1.035025	0.497742	1.03503	25th
22	Basic Boolean Operation	1.2710355	1.020034	0.499155	1.020041	26th
26	Mod	1.2579168	1.008056	0.500295	1.008065	27th
42	Memory Clear	1.2549056	1.005308	0.500559	1.005317	28th
62	Degrees	1.2456592	0.996873	0.50137	0.996883	29th
40	Memory Store	1.232003	0.984424	0.502577	0.984436	30th
16	Exp Functions & Log	1.2259006	0.978865	0.50312	0.978878	31st
10	Basic Notation	1.2145486	0.968529	0.504136	0.968544	32nd
41	Memory Recall	1.2123174	0.966498	0.504337	0.966514	33rd
73	Add	1.2116551	0.965896	0.504397	0.965911	34th
56	Pi	1.2102018	0.964573	0.504527	0.964589	35th
25	Percentage (%)	1.2096105	0.964035	0.504581	0.964051	36th
77	Parsing	1.1878397	0.944241	0.506557	0.944263	37th
65	Enable Calculator Functions	1.1775345	0.934882	0.507503	0.934906	38th
78	Number Conversion	1.1664949	0.924862	0.508523	0.924891	39th
7	Systems	1.1525456	0.912214	0.509824	0.912249	40th
33	Binary Numbers Display	1.1331551	0.894652	0.511653	0.894698	41st
47	Binary number set	1.1263732	0.888516	0.512298	0.888566	42nd
38	CAD	1.0784715	0.845263	0.516947	0.84536	43rd

Table 5.41: Options Prices and Development Priorities of SCS's Features (from 1st to 43rd)

Feature #	Features	Options	Option Price			Development Priority
		ROFS	Call	Put	Option Value	
81	Size Selection Button	1.0707454	0.838302	0.517712	0.83841	44th
67	Inverse-On	1.0619919	0.83042	0.518584	0.830542	45th
37	Backspace	1.0447099	0.814876	0.520323	0.815031	46th
36	CE	1.0387657	0.809535	0.520926	0.809703	47th
75	Unexpected Input Handling	1.0337708	0.805049	0.521434	0.805229	48th
31	Error messages Display	1.0314918	0.803003	0.521667	0.803189	49th
72	Scientific Notation Editing	1.0283559	0.800188	0.521988	0.800382	50th
71	Arcs	1.0166633	0.789699	0.523192	0.789927	51th
86	Menu	1.0128286	0.786261	0.523589	0.786501	52th
12	Memory	1.0089381	0.782775	0.523993	0.783028	53th
51	Letter Numbers	0.9980943	0.773064	0.525125	0.773358	54th
34	Statistics Data Display	0.9960416	0.771226	0.525341	0.771529	55th
80	Systems Selection Button	0.985719	0.761993	0.52643	0.762341	56th
32	Operations History Display	0.9813671	0.758102	0.526891	0.758472	57th
13	History	0.9570223	0.736369	0.529503	0.736885	58th
68	Inverse--Off	0.9481481	0.72846	0.530468	0.729042	59th
15	Unique Operations	0.9418143	0.722819	0.53116	0.723453	60th
48	Octane number Set	0.9316693	0.713791	0.532278	0.71452	61st
24	Statistics Operations	0.9286602	0.711115	0.532611	0.711874	62nd
44	Binary	0.9192464	0.702749	0.533658	0.703611	63rd
20	SCTH Functions	0.8505415	0.641945	0.541559	0.644122	64th
84	Statistics Dialog Box	0.8497971	0.641289	0.541648	0.643488	65th
54	Dword Number Set	0.8102616	0.606522	0.546417	0.610237	66th
61	Qword	0.8024554	0.599678	0.547378	0.603793	67th
45	Octane	0.7694351	0.570804	0.551525	0.577129	68th
46	Hexadecimal	0.7692201	0.570617	0.551553	0.576959	69th
23	Extra Boolean Operation	0.7450669	0.549581	0.55467	0.558225	70th
9	Angle	0.738929	0.544247	0.555474	0.553591	71st
17	Ln	0.7329878	0.539088	0.556256	0.549162	72nd
66	Disable Calculator Functions	0.7274168	0.534255	0.556994	0.545062	73rd
63	Radians	0.7238042	0.531123	0.557475	0.542432	74th
55	Qword Number Set	0.6869827	0.499304	0.562477	0.517136	75th
60	Dword	0.6852505	0.497811	0.562717	0.516024	76th
64	Grads	0.6782667	0.4918	0.563689	0.511621	77th
85	Binary Numbers Dialog Box	0.6665162	0.481701	0.56534	0.504528	78th
57	2Pi	0.6626927	0.478419	0.565882	0.502311	79th
11	Scientific Notation	0.6466359	0.464662	0.568182	0.493537	80th
27	Int & Dms	0.6318853	0.45206	0.57033	0.48632	81st
19	n!	0.5946906	0.420442	0.575908	0.472419	82nd
83	History Dialog Box	0.5357221	0.37083	0.585264	0.466531	83rd
28	Frac & Deg	0.5190274	0.35691	0.588039	0.46917	84th
18	e Function	0.5163387	0.354674	0.588491	0.469787	85th
21	SCTHI Functions	0.3870111	0.249227	0.612372	0.553243	86th

Table 5.42: Options Prices and Development Priorities of SCS's Features (from 44th to 86th)

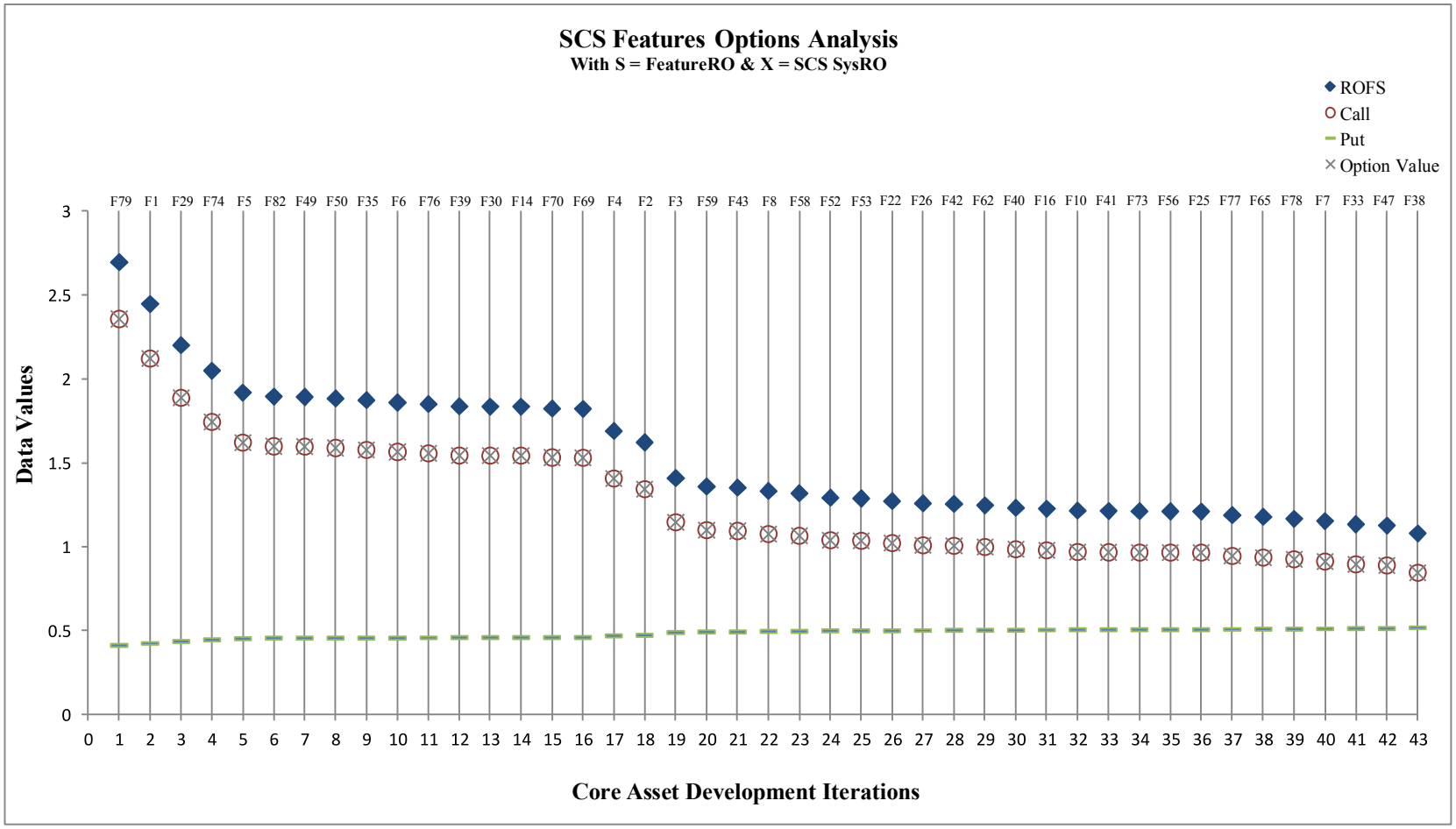

Figure 5.12: SCS Features Options Analysis (Features from 1st to 43rd)

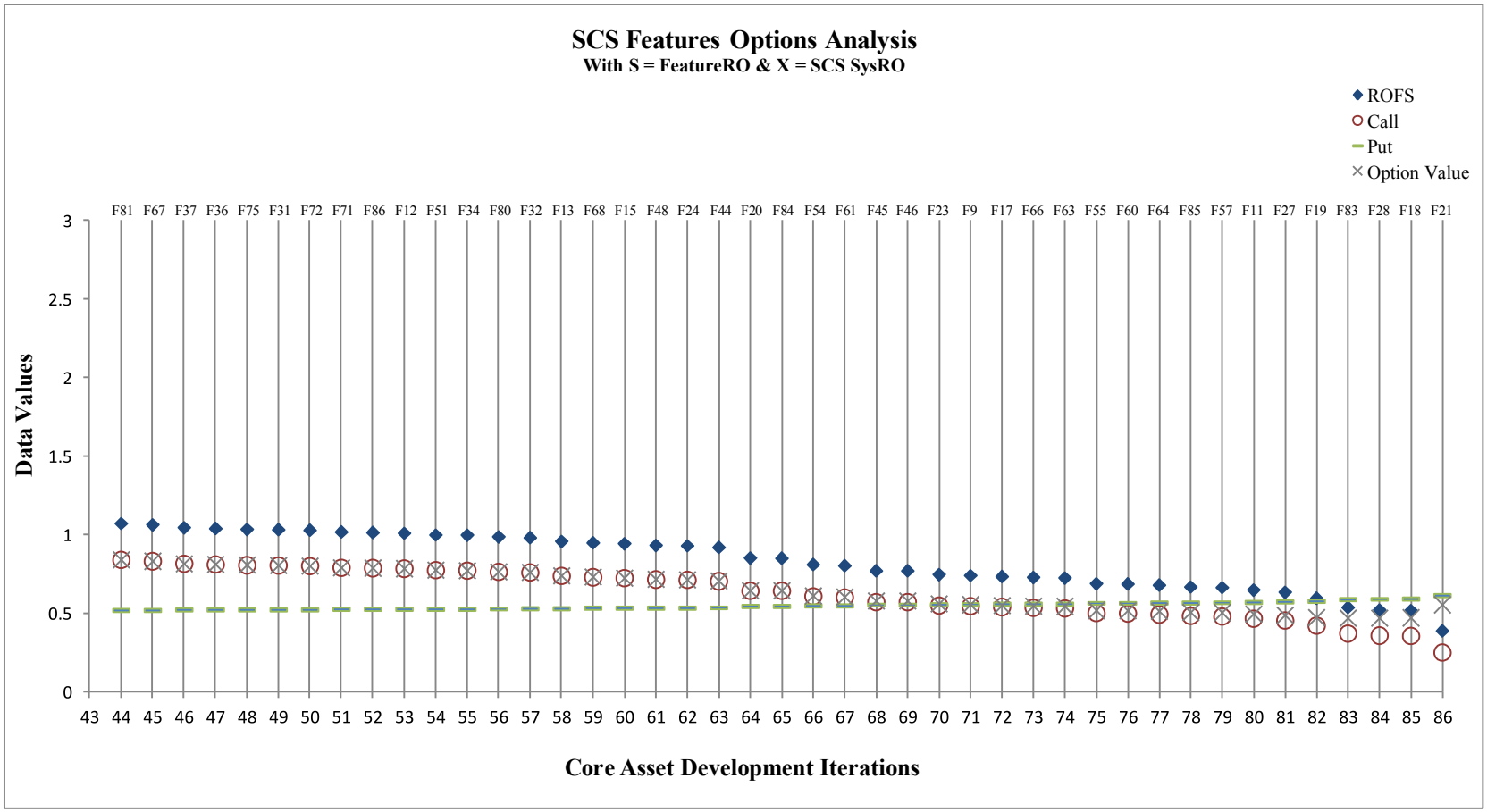

Figure 5.13: SCS Features Options Analysis (Features from 44th to 86th)

5.3 Results Summary

Chapter Five shown and discussed the results of the application of our framework into the case studies shown in Chapter Four. The results are analyzed from the viewpoint of each case study where there are number of factors that can be observed, from the results of the framework phases. For each case study, first, we generated the SPL Dataset which contains information about the operational features and their MPP attributes. Second, the SPL features dependencies relations will be debated. We presented number of figures and tables to illustrate the features dependencies relations and relations weights. Then the results of the classification process were shown and discussed. Next, we compute each reuse opportunity factor for each feature and features sets followed by the results of computing SPL Features Sets Reuse opportunity with a discussion of the effect of each Reuse opportunity factor. And finally, the SPL Features Sets development priorities results from ROT Options Analysis processes were illustrated within number of figures and tables. Table 5.43; shows brief comparison between the two case studies results.

	ESC	*SCS*	*Notes*
Number of Features	*29*	*116*	
Operational Features	*25*	*86*	
Common Features	*18*	*38*	
Optional Features	*7*	*48*	
Features Dependencies			*Each of them has all type of dependencies relations.*
Number of clusters (Features Sets)	*15*	*27*	*Clustering process based on theirs dependencies relations types and weights.*
Reuse Opportunity			*Computed based on the identified factors (FSFM, FSMPPF, and FSDF).*
Options Pricing			*In the two case studies feature (Features Set) that has the highest reuse opportunity has the highest Call price and lowest Put price.*
Features Sets Priority			*In the two case studies feature (Features Set) that has higher Call price has more priority to develop at the earlier developing iterations.*

Table 5.43: A Brief Comparison between case studies

By comparing the results of Appling our framework into the two case studies we note that the behavior of the framework phases results are the same for two case studies which helps to generalize the results for any other software product line.

CHAPTER 6

Conclusions and Future Work

In this chapter, the work has been done throughout the thesis is summarized and evaluated. We also present some suggestions for future work.

6.1 Summary of the work

As outlined in *Chapter One*, the main objective of this thesis was, addressing the key challenges associated with the *SPL* core asset development process by handling the uncertainty on *SPL* features selection. This main objective was broken down into number of smaller objectives step that were:

- Analyzed *SPL* features dependencies relations to classifying these features into a number of *Features Sets*.
- Developed a process to identify *Reuse Opportunities* for the *Features Sets* based on *SPL Marketing Product Plan* (*MPP*) and *Features Sets* dependencies relations.
- Identified the *Development Priority* for *SPL Features Sets* in core asset development based on their *Reuse Opportunities*.
- Managed *Software Product Line* core asset development uncertainty based on the *Real Options Theory* concept
- And finally, analyzed the impact of the process on the *SPL* development based on case studies.

We developed the *Software Product Line Engineering Management Framework* (*K-SPLEMF)* for core asset development. The main contributions of our work are:

- Identify a method to classify an *SPL* features into *Features Sets* based on their dependencies relations.
- Introduce new matrix to calculate features and *Features Sets Reuse Opportunities*.
- Prioritize features and *Features Sets* in the *SPL* core asset development process by using *ROT* concepts.
- Furthermore, analyze and discuss the results of the framework application on the *SPL* core asset development through two case studies.

6.2 Discussion

In this section the major lessons learned are as follow:

Product line engineering has become an important and widely used approach for efficiently developing portfolios of software products [5]. It is one of the recent and effective reuse approaches [6]. Despite the large number of research and studies that touched *SPL*, there is a gap in the study of uncertainty associated with features selection in the core asset development.

Feature binding provides essential information for product line asset development. This information includes which (*Binding Unit*) and when (*Binding Time*) product features are included in products [46]. The previous researches shown how to group a set of features (binding unit) based on features hierarchical relations (i.e. *composed-of, generalization/specialization,* and *implemented-by*) and features types, they didn't taken into account the features dependencies relations for binding units. Also, for binding time they talked about if the feature should be include to the product at building time or installation time, they didn't touched if feature or group of features should be developed at the earliest or latest *SPL* core asset development iterations.

There are different dependency types between *SPL* features [52]. *Usage, Modification,* and *Activation* dependencies between features have important implications on reusability and adaptability of product line assets development [55]. The previous researches discussed the impact of those dependency relations from the perspective of component and system architecture and design.

Real Options Theory offers a systematic approach to identify and assess the issues that have an effect on the real options value, which help companies to make a decision under uncertainty [25]. The benefit of real options approach appears on helping managers to plan and manage strategic investments through their available opportunities [23]. Real options are used in *IT* production investments evolution; and production risks identification, measurement and management [67]. However, to the best of our knowledge, no one of the previous researches has been addressed the uncertainty problem associated with features selection in the *SPL* core asset development.

Through what have been done in this thesis and form the application of our framework into the case studies we draw the following conclusions:

- The leaf features in the *SPL* feature model are actually contained code fragments that we identified as the *Operational Features*.

- The *Operational* and *Activation* dependencies relations between features are analyzed, identified, weighed, and used to classify features into number of *Features Sets*. *Positive weight* of the relation between two features means that these features should be in the *same Features Set*. The *negative weight* means that these features should be in *separated Features Sets*.

- The *Reuse Opportunity* of features and *Features Sets* is calculated through three factors: *Feature Model* factor (*feature type*); features *MPP* attributes factor; and *Dependencies* relations factor. Each factor and sub-factor has its impact on the *Reuse Opportunity* calculation process.

- Features and *Features Sets* that have *larger Reuse Opportunity* values (*compared to System and/or other features*) have *larger Call Option Price and lower Put Option Price*). However, those ones with *smaller Reuse Opportunity* have *larger Put Option Price* and *lower Call Option Price*.

- *ROT* is used to prioritize features and *Features Sets* in *SPL* core asset development interactions based on their *Call Option* values that are more than theirs *Put Option* values. On the other hand, when *Put Option* value of a feature or *Features Set* is *lower than* its *Call Option* value means that this feature or *Features Set* should be *postponed* to the *latest* development interactions.

- *Chooser Option* of a feature or *Features Set* follows the *larger Option* value (*Call Option or Put Option*) *of* the feature and/or *Features Set* (i.e. gives indication for the best choose *Call* or *Put*).

- *K-SPLEMF* is used to handle the uncertainty problem associated with feature selection in the *SPL* core asset development process. The impact of our framework was shown through case studies results. From these results, it can be seen that our framework is scalable and it can be generalized for all *SPL*.

- Although we analyzed the product line *Feature Model* and features dependencies, this thesis does not focus on the features and features' dependencies *implementation*. However, it must be noted that the main concern of this thesis is to identify ***when*** features and/or *Features Sets* should be developed ***not how*** they will be developed or implement. Implementation of a feature *(or Features Set contains number of features (common and/or optional)),* which has number of dependencies relations with other features, was discussed in many researches (e.g. [52, 55, 58]). This issue is out of the scope of our work.

As any academic research, there will be some limitations related to the work methodology; used data; available tools; the needed time and effort; etc. For these reasons and others our work has some limitations that could be as follow:

The framework was applied into two case studies. There is a need to apply it into more case studies to support framework generalization.

The *Feature Model* used in this thesis is build based on *FODA* approach. There are other approaches for feature modeling that didn't studied.

The *Weighing Process, which is applied on our case studies and some other examples and gave us the features classification (Features Sets)*, needs a mathematical prove to be confident for any *SPL* system.

6.3 Future work

It is certain that the work presented in this thesis will not be the final word on *SPLE* management. Therefore, in the future we intend to:

Replicate this experiment by application of our framework on other *SPL* systems in order to support our findings; take into account the feature type during the *Classification Process* in addition to features dependencies relations; using other dependencies relation (*e.g. Configuration Dependency*) in the *Classification Process*; using other tools for *Classification Process* rather than *Pajek*; using more attributes from feature *MPP* to compute *MPP* factor and *Reuse Opportunity* values (*e.g. binding technology, user profiles skill level, time to market, etc*); using *Feature Cost* and *Feature Size* as factors in addition to our three factors to compute feature and *Features Set Reuse Opportunity*; using other *ROT* formulas to compute the option price in addition to *Black-Scholes* and *Chooser Option* formulas; furthermore, we intend to develop our special tool to implement the whole framework phases.

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Appendix A: Elevator System Control (ESC)

ESC Features Description

1. Passenger Service: *Passenger Service* in the *ECS* product line is a normal driving service of an elevator. During the operation of *Passenger Service*, the elevator registers calls from passengers in the halls or within the car; answers the calls by moving the car to the requested floors; and controls (i.e., opens or closes) doors when it stops.
2. VIP Service: *VIP Service* indicates a driving service an elevator provides for *VIPs*. When it is activated by the landing key switch, a car moves to a predefined floor and waits for a car call after opening doors. If a car call is entered and the door close button is pressed, the car will serve the car call. When no car call is entered within the present time, the car will close its doors and resume *Passenger Service*.
3. Fire Fighter Service: *Fire Fighter Service* may be activated using a key switch in a car and places an elevator under the control of a fire fighter. The behavior of this feature must be in compliance with the local laws. In this research, we assume that the car starts traveling while a car call button is being pressed and stops at the requested floor with doors closed. The doors can be opened only while the door open button is being pressed. If the button is released, the doors are closed immediately.
4. 4. Car Call Cancellation: When a car has responded to the final car call in one direction, the system regards remaining calls in the other direction as mistakes and clears them from the memory.
5. Car Call Registration: Is an operation for registering passenger's call requests from the car.
6. Anti-Nuisance: Cancels all car calls if an excessive number of car calls are registered for the passenger load determined by the weight sensor.
7. Hall Call Registration: Is an operation for registering passenger's call requests from the Hall.
8. Auto Door Open: To open an automatic door when car is completely stopped.
9. Door Open Button: Permits to open or re-open an automatic door, and to keep it open by constant pressure.
10. Auto Door Close: To close an automatic door immediately when car has to start moving.
11. Door Close Button: Causes the remaining door dwell time to be canceled and the doors begin to close immediately.
12. Auto Start: Auto registers a request for an elevator to move based on the requested call direction and the elevator position after door is closed.
13. Call Button Start: Registers a request for an elevator to move based on the requested call direction and the elevator position after door is closed in the fire fighter service.
14. Speed Control: Is a control operation for acceleration and deceleration of the elevator.
15. Load Weighing Bypass: When a car is loaded to a predetermined percent of capacity, the weight sensing devices will operate causing that car to bypass further hall calls (i.e. car will not stop based on hall calls).
16. Registered Floor Stop: Determines the landing floors of an elevator.
17. Call Data Management: Manages the requested calls from the hall and car.
18. Direction Control: Compute the next movement direction of an elevator based on current position data from position control.
19. Position Control: Calculate the current position of an elevator based on position sensor inputs.
20. Car Move: Moves the elevator to the requested floor.
21. Car Stop: Stops the elevator at the requested floor.
22. Car Button: Used by passengers to register car calls, door open and close, …, etc.
23. Hall Button: Used to request the elevator to a hall.
24. Weight Sensor: Dedicate the current weights of passengers on an elevator.
25. Position Sensor: Dedicate the current position of an elevator.

ECS Features Marketing Product Plan Attributes

	Features	*Feature Type*	*MPP Attributes*			
			Need Assessment	*Price Range*	*Feature coverage*	*Feature Binding*
1	Passenger Service	Common	H	H|L	A	B
2	VIP Service	Optional	H|L	H|L	A|S	I
3	Fire Service	Optional	H|L	H|L	A|S	I
4	Car Call Cancellation	Optional	H|L	H|L	A|S	I
5	Car Call Registration	Common	H	H|L	A	B
6	Anti-Nuisance	Optional	H|L	H|L	A|S	I
7	Hall Call Registration	Common	H	H|L	A	B
8	Auto Door Open	Common	H	H|L	A	B
9	Door Open Button	Common	H	H|L	A	B
10	Auto Door Close	Common	H	H|L	A	B
11	Door Close Button	Common	H	H	A	B
12	Auto Start	Common	H	H|L	A	B
13	Call Button Start	Optional	H|L	H|L	A|S	I
14	Speed Control	Common	H	H|L	A	B
15	Load Weighing Bypass	Optional	H|L	H|L	A|S	I
16	Registered Floor Stop	Common	H	H|L	A	B
17	Call Data Management	Common	H	H|L	A	B
18	Direction Control	Common	H	H|L	A	B
19	Position Control	Common	H	H|L	A	B
20	Car Move	Common	H	H|L	A	B
21	Car Stop	Common	H	H|L	A	B
22	Car Button	Common	H	H|L	A	B
23	Hall Button	Common	H	H|L	A	B
24	Weight Sensor	Optional	H|L	H|L	A|S	I
25	Position Sensor	Common	H	H|L	A	B

Table A 1: ECS Features MPP Attributes

ECS features Dependencies information Adjustment

This process aims to adjust the information of *ECS* features relations dependencies shown in *Table 5.2*; to be appropriate for the weighting process. This *Adjustment Process* includes two steps:

- Transferring:

In this step, we transfer letters refer to *Modification*, *Subordinate-Activation* and *Sequential-Activation* relations (M, *S and Q respectively*) from the table rows to the corresponding columns as shown in *Table A.2*; and then for each feature in the table rows we count how many relations it has with features in the table columns as shown in the last six columns in *Table A.2*.

For example if features *A*, *B* , and *C* depend on features *D* in term of *Modification*, that means when we compute feature dependencies (during *Reuse Opportunity Calculations*) , features *D* has *3* features depend on its relation, and each one of features *A*, *B*, and *C* have *0*. On the other hand, during the *Classification Process* each one of features *A*, *B*, and *C* has one feature affect each one of them respectively, and *D* has *0*. The same thing could be said for *Subordinate-Activation* and *Sequential-Activation* dependencies relations.

- Removing:

As illustrated in *Chapter 3, Concurrent-Activation* and *Exclusive-Activation* are *Correlations Dependencies* relations. So that, they appeared in *Table 5.2*; and *Table A.2*; twice for each two features (from feature in the table row to feature in the table column and v.v.). For each two features these letters (*E* and *C*) refer to the same relations between the same two features respectively. So that, we remove the letters that refer to these relations from one side (*i.e. other feature will keep its letter that refers to the relation*). The results of this *Adjustment Process* are shown in *Table A.3*.

For example, if feature *A, B, C* have *Concurrent-Activation* with feature *D*, and as discussed in *Chapter 3* that *Concurrent-Activation* is a coloration relation which means that *D* has *Concurrent-Activation* with each one of features *A, B,* and *C*. so that, during the *Classification Process* we count *3* relations from each one of *A, B,* and *C* to *D*. on the other hand, during the computation of *Dependency Factors* we count *6* relations (*3* form *C*'s side and *3* from each one of *A*'s, *B*'s, and *C*'s sides).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Number of features that is					
	Feature	Passenger Service	VIP Service	Fire Service	Car Call Cancellation	Car Call Registration	Anti-Nuisance	Hall Call Registration	Auto Door Open	Door Open Button	Auto Door Close	Door Close Button	Auto Start	Call Button Start	Speed Control	Load Weighing Bypass	Registered Floor Stop	Call Data Management	Direction Control	Position Control	Car Move	Car Stop	Car Button	Hall Button	Weight Sensor	Position Sensor	Use	Modify	Subordinate-activate (superior)	exclude-activate	concurrent-activate	sequential-activate
1	Passenger Service	-	E	E	-	-	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	3	0	0
2	VIP Service	E	-	E	E	-	E	E	-	-	E	-	-	E	-	E	-	-	-	-	-	-	-	E	E	-	0	0	0	10	0	0
3	Fire Service	E	E	-	E	-	E	E	E	-	-	E	E	-	-	E	-	-	-	-	-	-	-	E	E	-	0	0	0	11	0	0
4	Car Call Cancellation	S	E	E	-	E	-	C	-	-	-	-	C	-	C	C	C	C	C	-	-	-	C	-	-	-	0	0	1	3	8	0
5	Car Call Registration	US	US	US	ME	-	-	C	-	-	-	Q	C	Q	C	C	C	C	C	-	-	-	C	-	-	-	3	1	3	1	8	2
6	Anti-Nuisance	US	E	E	-	Q	-	C	-	-	-	-	C	-	C	C	C	C	C	-	-	-	-	-	C	-	1	0	1	2	8	1
7	Hall Call Registration	US	E	E	C	C	C	-	-	-	-	-	C	-	C	C	C	C	C	-	-	-	-	C	-	-	1	0	1	2	10	0
8	Auto Door Open	US	US	E	-	-	-	-	-	-	E	E	-	-	-	-	-	-	-	C	E	Q	-	-	-	-	2	0	2	4	1	1
9	Door Open Button	US	US	US	-	-	-	-	-	-	E	E	-	-	-	-	-	-	-	C	E	Q	-	-	-	-	3	0	3	3	1	1
10	Auto Door Close	US	E	US	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	C	E	Q	-	-	-	-	2	0	2	4	1	1
11	Door Close Button	US	US	E	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	C	E	Q	-	-	-	-	2	0	2	4	1	1
12	Auto Start	S	S	E	C	C	C	C	-	-	-	-	-	-	-	-	-	C	C	C	UC	-	-	-	-	-	1	0	2	1	8	0
13	Call Button Start	E	E	S	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	1	0	1	2	1	1
14	Speed Control	US	US	US	C	CQ	C	C	-	-	-	-	-	-	-	-	-	C	C	C	-	-	-	-	-	-	3	0	3	0	7	1
15	Load Weighing Bypass	S	E	E	C	C	C	C	-	-	-	-	-	-	-	-	-	C	C	C	-	-	-	-	C	-	0	0	1	2	8	0
16	Registered Floor Stop	S	S	S	C	CQ	C	C	-	-	-	-	-	-	-	M	-	C	C	C	-	UC	-	-	-	-	1	1	3	0	8	1
17	Call Data Management	S	S	S	UC	UC	UC	UC	-	-	-	-	UC	U	C	UC	UC	-	UC	C	-	-	-	-	-	-	9	0	3	0	10	0
18	Direction Control	S	S	S	C	CQ	C	C	-	-	-	-	UC	U	UC	UC	UC	C	-	UC	-	-	-	-	-	-	6	0	3	0	10	1
19	Position Control	S	S	S	-	-	-	-	UC	UC	UC	UC	UC	U	UC	UC	UC	C	UC	-	C	C	-	-	-	C	10	0	3	0	13	0
20	Car Move	US	US	US	-	-	-	-	E	E	E	E	C	C	-	-	-	-	-	C	-	E	-	-	-	-	3	0	3	5	3	0
21	Car Stop	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	E	-	-	-	-	-	3	0	3	1	2	0
22	Car Button	S	S	S	UC	UC	-	-	-	U	-	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	5	0	3	0	2	0
23	Hall Button	S	E	E	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	2	1	0
24	Weight Sensor	S	E	E	-	-	UC	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	2	0	1	2	2	0
25	Position Sensor	S	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	1	0	3	0	1	0

Table A.2: ECS Features Dependencies after Adjustment Transferring Process

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Feature	Passenger Service	VIP Service	Fire Service	Car Call Cancellation	Car Call Registration	Anti-Nuisance	Hall Call Registration	Auto Door Open	Door Open Button	Auto Door Close	Door Close Button	Auto Start	Call Button Start	Speed Control	Load Weighing Bypass	Registered Floor Stop	Call Data Management	Direction Control	Position Control	Car Move	Car Stop	Car Button	Hall Button	Weight Sensor	Position Sensor
1	Passenger Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	VIP Service	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Fire Service	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Car Call Cancellation	S	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Car Call Registration	US	US	US	ME	-	-	-	-	-	-	Q	-	Q	-	-	-	-	-	-	-	-	-	-	-	-
6	Anti-Nuisance	US	E	E	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Hall Call Registration	US	E	E	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Auto Door Open	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
9	Door Open Button	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
10	Auto Door Close	US	E	US	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
11	Door Close Button	US	US	E	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
12	Auto Start	S	S	E	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-
13	Call Button Start	E	E	S	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-
14	Speed Control	US	US	US	C	CQ	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Load Weighing Bypass	S	E	E	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Registered Floor Stop	S	S	S	C	CQ	C	C	-	-	-	-	-	-	-	M	-	-	-	-	-	U	-	-	-	-
17	Call Data Management	S	S	S	UC	UC	UC	UC	-	-	-	-	UC	U	C	UC	UC	-	U	-	-	-	-	-	-	-
18	Direction Control	S	S	S	C	CQ	C	C	-	-	-	-	UC	U	UC	UC	UC	C	-	U	-	-	-	-	-	-
19	Position Control	S	S	S	-	-	-	-	UC	UC	UC	UC	UC	U	UC	UC	UC	C	UC	-	-	-	-	-	-	-
20	Car Move	US	US	US	-	-	-	-	E	E	E	E	C	C	-	-	-	-	-	C	-	-	-	-	-	-
21	Car Stop	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	E	-	-	-	-	-
22	Car Button	S	S	S	UC	UC	-	-	-	U	-	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-
23	Hall Button	S	E	E	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Weight Sensor	S	E	E	-	-	UC	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-
25	Position Sensor	S	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-

Table A.3: ECS Features Dependencies after Adjustment Removing Process

ECS Features and Features Relations Weights

*Vertices 25	1 12 -3	3 4 -4	5 15 -4	11 21 1
1 "F1"	1 13 -4	3 5 -8	5 16 -3	11 22 -5
2 "F2"	1 14 -8	3 6 -4	5 17 -9	12 17 -9
3 "F3"	1 15 3	3 7 -4	5 18 -3	12 18 -9
4 "F4"	1 16 -3	3 8 -4	5 22 -9	12 19 -9
5 "F5"	1 17 -3	3 9 -8	6 7 -4	12 20 1
6 "F6"	1 18 -3	3 10 -8	6 12 -4	13 17 -5
7 "F7"	1 19 -3	3 11 -4	6 14 -4	13 18 -5
8 "F8"	1 20 -8	3 12 -4	6 15 -4	13 19 -5
9 "F9"	1 21 -8	3 13 3	6 16 -4	13 20 1
10 "F10"	1 22 -3	3 14 -8	6 17 -9	13 22 -5
11 "F11"	1 23 3	3 15 -4	6 18 -4	14 17 -4
12 "F12"	1 24 3	3 16 -3	6 24 -9	14 18 -9
13 "F13"	1 25 -3	3 17 -3	7 12 -4	14 19 -9
14 "F14"	2 3 -4	3 18 -3	7 14 -4	15 16 2
15 "F15"	2 4 -4	3 19 -3	7 15 -4	15 17 -9
16 "F16"	2 5 -8	3 20 -8	7 16 -4	15 18 -9
17 "F17"	2 6 -4	3 21 -8	7 17 -9	15 19 -9
18 "F18"	2 7 -4	3 22 -3	7 18 -4	15 24 -9
19 "F19"	2 8 -8	3 23 -4	7 23 9	16 17 -9
20 "F20"	2 9 -8	3 24 -4	8 10 -4	16 18 -9
21 "F21"	2 10 -4	3 25 -3	8 11 -4	16 19 -9
22 "F22"	2 11 -8	4 5 -2	8 19 -9	16 21 1
23 "F23"	2 12 -3	4 7 -4	8 20 -4	17 18 -9
24 "F24"	2 13 -4	4 12 -4	8 21 1	17 19 -4
25 "F25"	2 14 -8	4 14 -4	9 10 -4	18 19 -14
*Edges	2 15 -4	4 15 -4	9 11 -4	19 20 -4
1 2 -4	2 16 -3	4 16 -4	9 19 -9	19 21 -4
1 3 -4	2 17 -3	4 17 -9	9 20 -4	19 25 9
1 4 3	2 18 -3	4 18 -4	9 21 1	20 21 -4
1 5 -8	2 19 -3	4 22 -9	9 22 -5	
1 6 8	2 20 -8	5 6 1	10 13 1	
1 7 8	2 21 -8	5 7 -4	10 19 -9	
1 8 -8	2 22 -3	5 11 -1	10 20 -4	
1 9 -8	2 23 -4	5 12 - 4	10 21 1	
1 10 -8	2 24 -4	5 13 -1	11 19 -9	
1 11 -8	2 25 -3	5 14 -3	11 20 -4	

Figure A.1: Input Text file for Pajek of ECS Features and Features Relations Weights

(The original text file is one column)

Pajek ECS Features Classifications

ECS Features Classification (Pajek Result Graph at Number of Clusters = 1)

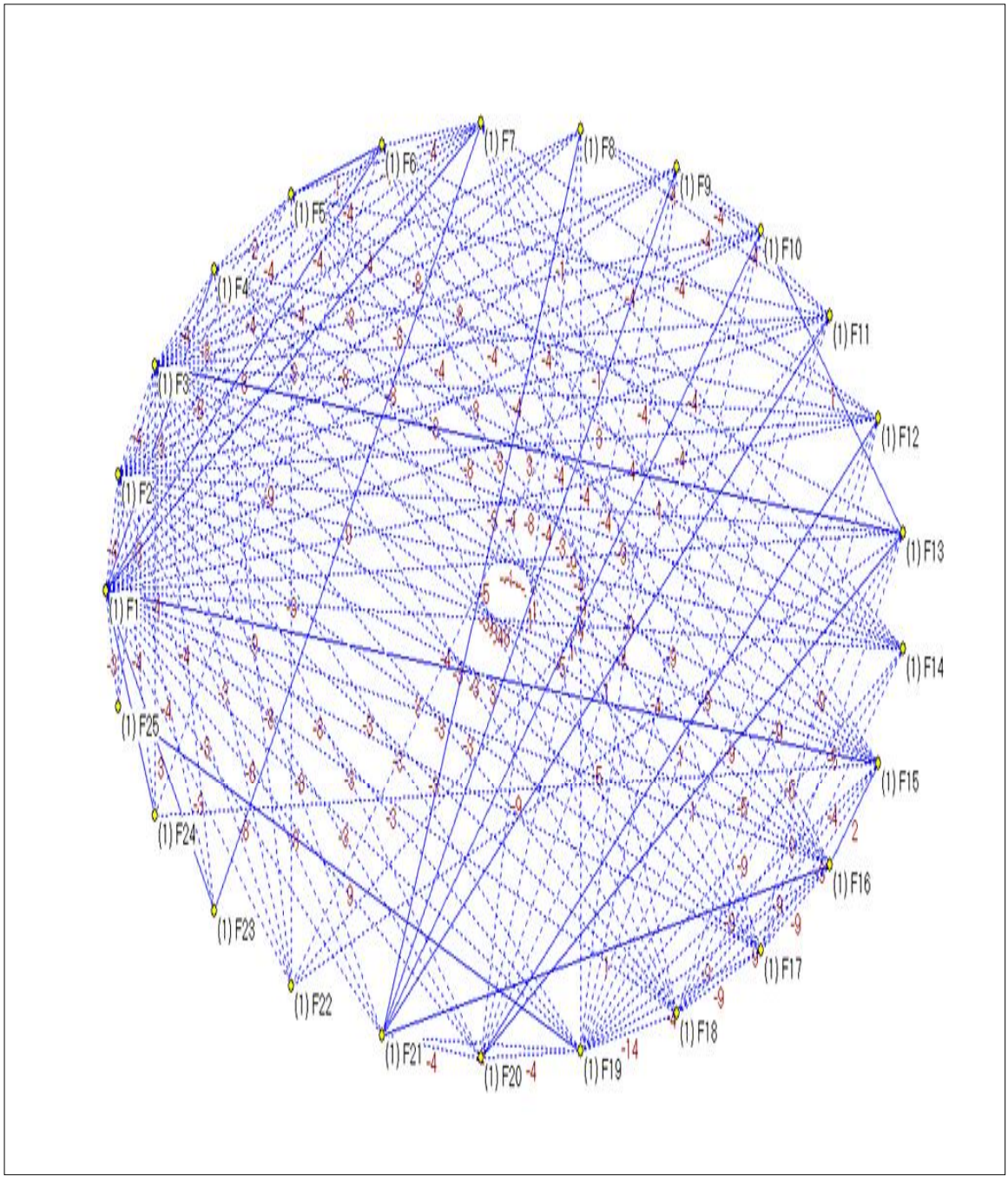

Figure A.2: ECS Features Classification (Pajek Result at Number of clusters = 1)

ECS Features Classification (Pajek Result Report at Number of Clusters = 1)

```
Reading Network   ---   G:\Thesis\Thesis Experiments\ECS\ECS Pajek results\ECS-pacjek-data.
-------------------------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------
                Working...
            178 lines read.
          Time spent:  0:00:00
-------------------------------------------------
    Signed graphs: positive diagonal
  blocks, negative off-diagonal blocks
-------------------------------------------------
                Working...
     Number of clusters: 25, alpha:
      0.500, min size of clusters: 1
     -------  Starting partition -------
        Errors:     60.00      Lines
     -----------------------------------
           3.00 :      1-4
           8.00 :      1-6
           8.00 :      1-7
           3.00 :     1-15
           3.00 :     1-23
           3.00 :     1-24
           3.00 :     3-13
           1.00 :      5-6
           9.00 :     7-23
           1.00 :     8-21
           1.00 :     9-21
           1.00 :    10-21
           1.00 :    10-13
           1.00 :    11-21
           1.00 :    12-20
           1.00 :    13-20
           2.00 :    15-16
           1.00 :    16-21
           9.00 :    19-25
     -----------------------------------
     -------    Improvements    -------
     -------  Final partition  1-------
        Errors:     60.00      Lines
     -----------------------------------
                       .
                       .
                       .
          -3.00 :     1-25          -3.00 :     3-25          -9.00 :     6-17
          -4.00 :     1-2           -4.00 :     3-4           -4.00 :     6-18
          -4.00 :     1-3           -8.00 :     3-9           -4.00 :     7-12
          -8.00 :     1-5           -8.00 :    3-10           -4.00 :     7-14
          -8.00 :     1-8           -4.00 :    3-11           -4.00 :     7-15
          -8.00 :     1-9           -4.00 :    3-12           -4.00 :     7-16
          -8.00 :    1-10           -8.00 :    3-14           -9.00 :     7-17
          -8.00 :    1-11           -4.00 :    3-15           -4.00 :     7-18
          -3.00 :    1-12           -3.00 :    3-16           -4.00 :     8-10
          -4.00 :    1-13           -3.00 :    3-17           -4.00 :     8-11
          -8.00 :    1-14           -3.00 :    3-18           -9.00 :     8-19
          -3.00 :    1-16           -3.00 :    3-19           -4.00 :     8-20
          -3.00 :    1-17           -8.00 :    3-20           -5.00 :     9-22
          -3.00 :    1-18           -8.00 :    3-21           -9.00 :    12-17
          -3.00 :    1-19           -3.00 :    3-22           -9.00 :    12-18
          -8.00 :    1-20           -4.00 :    3-23           -9.00 :    12-19
          -8.00 :    1-21           -4.00 :    3-24           -5.00 :    13-22
          -3.00 :    1-22           -9.00 :    4-22           -5.00 :    13-17
          -3.00 :    2-25           -2.00 :    4-5            -5.00 :    13-18
          -4.00 :    2-3            -4.00 :    4-7            -5.00 :    13-19
          -4.00 :    2-4            -4.00 :    4-12           -9.00 :    14-19
          -8.00 :    2-5            -4.00 :    4-14           -4.00 :    14-17
          -4.00 :    2-6            -4.00 :    4-15           -9.00 :    14-18
          -4.00 :    2-7            -4.00 :    4-16           -9.00 :    15-24
          -8.00 :    2-8            -9.00 :    4-17           -9.00 :    15-17
          -8.00 :    2-9            -4.00 :    4-18           -9.00 :    15-18
          -4.00 :   2-10            -9.00 :    5-22           -9.00 :    15-19
          -8.00 :   2-11            -4.00 :    5-7            -9.00 :    16-17
          -3.00 :   2-12            -1.00 :    5-11           -9.00 :    16-18
          -4.00 :   2-13            -1.00 :    5-13           -9.00 :    16-19
          -8.00 :   2-14            -3.00 :    5-14           -4.00 :    17-19
          -4.00 :   2-15            -4.00 :    5-15           -9.00 :    17-18
          -3.00 :   2-16            -3.00 :    5-16          -14.00 :    18-19
          -3.00 :   2-17            -9.00 :    5-17           -4.00 :    19-20
          -3.00 :   2-18            -3.00 :    5-18           -4.00 :    19-21
          -3.00 :   2-19            -9.00 :    6-24           -4.00 :    20-21
          -8.00 :   2-20            -4.00 :    6-7     -------------------------------------
          -8.00 :   2-21            -4.00 :    6-12       1 solution with 713.00
          -3.00 :   2-22            -4.00 :    6-14       inconsistencies found.
          -4.00 :   2-23            -4.00 :    6-15       Time spent:  0:27:38
          -4.00 :   2-24            -4.00 :    6-16
```

Figure A.3: Pajek Result Report for ECS Features Classification at Number of Clusters = 1

(The original text file is one column content 109345 lines)

ECS Features Classification (Pajek Result Graph at Number of Clusters = 15)

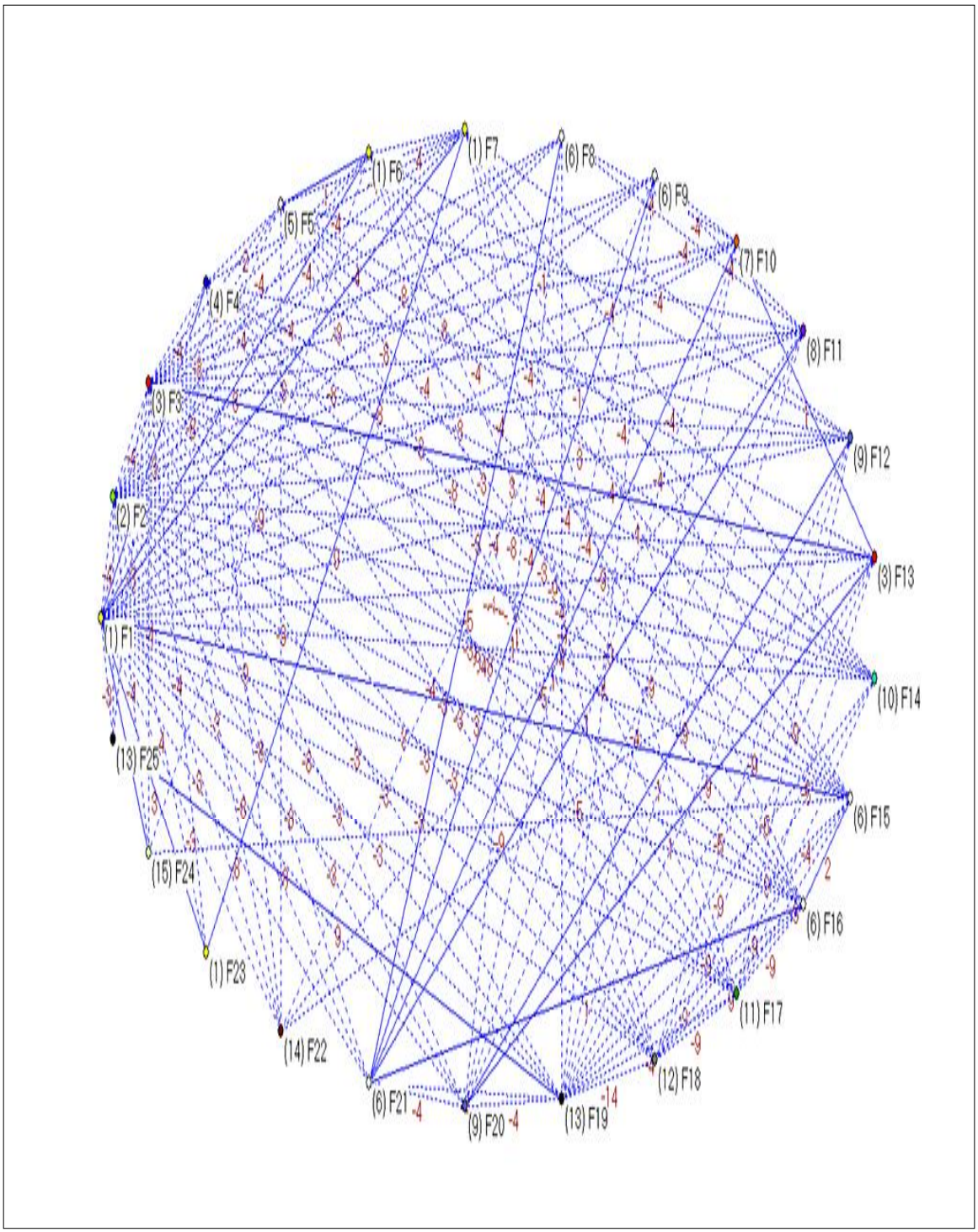

Figure A.4: ECS Features Classification (Pajek Result at Number of clusters = 15)

ECS Features Classification (Pajek Result Report at Number of Clusters = 15)

```
Reading Network   ---    G:\Thesis\Thesis Experiments\ECS\ECS Pajek results\ECS-pacjek-data.
-------------------------------------------------------------------------------------------------------------------------------------------------------------
                Working...                                                                                                                  .
             178 lines read.                    1.00 :     10-21          1.00 :     8-21                                                .
          Time spent:  0:00:00                  1.00 :     10-13          1.00 :     9-21                                                .
-------------------------------------------     1.00 :     11-21          1.00 :     10-21                                               .
  Signed graphs: positive diagonal              1.00 :     12-20          1.00 :     10-13                                    1.00 :     9-21
  blocks, negative off-diagonal blocks          1.00 :     13-20          1.00 :     11-21                                    1.00 :     10-13
-------------------------------------------     2.00 :     15-16          1.00 :     12-20                                    1.00 :     13-20
                Working...                      1.00 :     16-21          1.00 :     13-20                                    ----------------------------
  Number of clusters: 25, alpha:                9.00 :     19-25          2.00 :     15-16                                    ----  Final partition  2-------
  0.500, min size of clusters: 1                ----------------------------------------          9.00 :     19-25          Errors:     18.00      Lines
  -------  Starting partition -------          -------  Improvements  ------                    ----------------------------------------          ----------------------------
     Errors:     60.00      Lines                                -                                ----  Improvements  -----                    -4.00 :     6-7
  ----------------------------------                -------  Final partition  1-------             1:     21.00                                3.00 :     1-4
        3.00 :     1-4                          Errors:     60.00      Lines                      3:     20.00                                3.00 :     1-15
        8.00 :     1-6                          ----------------------------------------          7:     19.00                                3.00 :     1-24
        8.00 :     1-7                                3.00 :     1-4                             18:     18.00                                1.00 :     5-6
        3.00 :     1-15                               8.00 :     1-6                       ----  Final partition  1-------                   1.00 :     10-21
        3.00 :     1-23                               8.00 :     1-7                        Errors:     18.00      Lines                     1.00 :     10-13
        3.00 :     1-24                               3.00 :     1-15                      ----------------------------------------          1.00 :     11-21
        3.00 :     3-13                               3.00 :     1-23                           -4.00 :     6-7                          1.00 :     13-20
        1.00 :     5-6                                3.00 :     1-24                           3.00 :     1-4                           ----------------------------
        9.00 :     7-23                               3.00 :     3-13                           3.00 :     1-15                          2 solutions with 18.00
        1.00 :     8-21                               1.00 :     5-6                            3.00 :     1-24                          inconsistencies found.
        1.00 :     9-21                               9.00 :     7-23                           1.00 :     5-6                           Time spent:  0:16:04
                                                                                                 1.00 :     8-21
```

Figure A.5: Pajek Result Report for ECS Features Classification at Number of Clusters = 15

(The original text file is one column content 970 lines)

ECS Features Classification (Pajek Result Graph at Number of Clusters = 25)

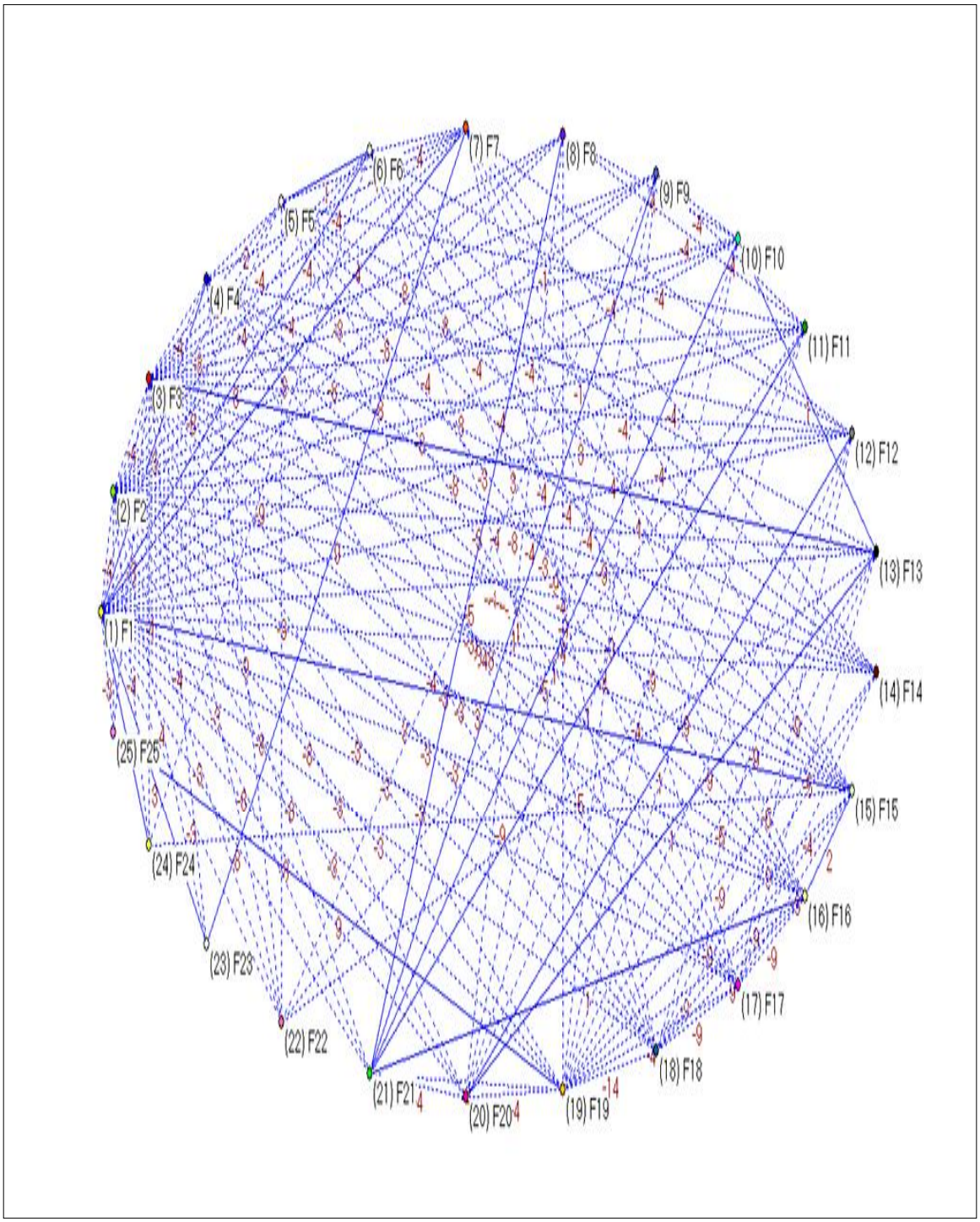

Figure A.6: ECS Features Classification (Pajek Result at Number of clusters = 25)

ECS Features Classification (Pajek Result Report at Number of Clusters = 25)

```
Reading Network   ---   G:\Thesis\Thesis Experiments\ECS\ECS Pajek results\ECS-pacjek-data.net
-------------------------------------------------------------------------------------------------------------------------------------------------------
                                                                                                                                                       
                                Working...                                                                                                             
                            178 lines read.                                                                                                            
                          Time spent:  0:00:00                                                                                                         
                ------------------------------------------------------                                                                                 
                Signed graphs: positive diagonal blocks,                                                                                               
                      negative off-diagonal blocks                                                                                                     
                ------------------------------------------------------                                                                                 
                                Working...                                                                                                             
                      Number of clusters: 25, alpha:                                                                                                   
                      0.500, min size of clusters: 1                                                                                                   
                      -------  Starting partition -------                                                                                              
                        Errors:      60.00       Lines                                                                                                 
                        -----------------------------------                                                                                            
                             3.00 :      1-4                                                                                                           
                             8.00 :      1-6                                                                                                           
                             8.00 :      1-7                                                                                                           
                             3.00 :      1-15                                                                                                          
                             3.00 :      1-23                                                                                                          
                             3.00 :      1-24                                                                                                          
                             3.00 :      3-13                                                                                                          
                             1.00 :      5-6                                                                                                           
                             9.00 :      7-23                                                                                                          
                             1.00 :      8-21                                                                                                          
                             1.00 :      9-21                                                                                                          
                             1.00 :      10-21                                                                                                         
                             1.00 :      10-13                                                                                                         
                             1.00 :      11-21                                                                                                         
                             1.00 :      12-20                                                                                                         
                             1.00 :      13-20                                                                                                         
                             2.00 :      15-16                                                                                                         
                             1.00 :      16-21                                                                                                         
                             9.00 :      19-25                                                                                                         
                        -----------------------------------                                                                                            
                        ----   Improvements   ------                                                                                                   
                        -----  Final partition 1 ------                                                                                                
                         Errors:      60.00       Lines                                                                                                 
                        -----------------------------------                                                                                            
                             3.00 :      1-4                                                                                                           
                             8.00 :      1-6                                                                                                           
                             8.00 :      1-7                                                                                                           
                             3.00 :      1-15                                                                                                          
                             3.00 :      1-23                                                                                                          
                             3.00 :      1-24                                                                                                          
                             3.00 :      3-13                                                                                                          
                             1.00 :      5-6                                                                                                           
                             9.00 :      7-23                                                                                                          
                             1.00 :      8-21                                                                                                          
                             1.00 :      9-21                                                                                                          
                             1.00 :      10-21                                                                                                         
                             1.00 :      10-13                                                                                                         
                             1.00 :      11-21                                                                                                         
                             1.00 :      12-20                                                                                                         
                             1.00 :      13-20                                                                                                         
                             2.00 :      15-16                                                                                                         
                             1.00 :      16-21                                                                                                         
                             9.00 :      19-25                                                                                                         
                        -----------------------------------                                                                                            
                        1 solution with 60.00                                                                                                          
                        inconsistencies found.                                                                                                         
                        Time spent:  0:02:12                                                                                                           
```

Figure A.7: Pajek Result Report for ECS Features Classification at Number of Clusters = 25

(The original text file is one column content 63 lines)

ECS Features Reuse Opportunity

Each feature in *ECS* product line has its attributes that are: *Feature Type, Feature MPP* attributes, and *Feature Dependencies* relations.

To compute *ECS* feature *Reuse Opportunity* (*FRO*) we use *Table 5.3*; and *Table A.1*; information and *Chapter 3*, equations for computing *FT*, *MPPF*, and *DF*.

FT is computed based on equations (10), (11), and (12); *MPPF* is computed (i.e. Each *H* and *A* will be counted as *1* however *H*/*L* and *A*/*S* will be generated syntactically) based on equations (15) to (19), and equation (24); *DF* was computed during the features dependencies analysis based on equations (4) to (9), and equation (25).

Table A.4; shows the results of the previous processes for each *ECS* feature.

Feature #	Features	FT	MPP Factors					Dependency Factors								FRO
			NA	PR	FC	FBTW	MPPF	FU	FMD	FSB	FEX	FCN	FSQ	DF	IDF	
1	Passenger Service	1	1	0.0567093	1	1	0.764177316	0	0	21	3	0	0	1	0.142857	2.764177316
2	VIP Service	0.5	0.53	0.0750799	0.2	0.5	0.326269968	0	0	14	10	0	0	1	0	1.826269968
3	Fire Service	0.5	0.7	0.0079872	0.93	0.5	0.534496805	0	0	13	11	0	0	1	0.043478	2.034496805
4	Car Call Cancellation	0.5	0.7	0.0455272	0.67	0.5	0.478881789	0	1	0	3	8	0	0.5	0	1.478881789
5	Car Call Registration	1	1	0.0127796	1	1	0.753194888	3	0	0	1	8	4	0.6666667	0	2.419861555
6	Anti-Nuisance	0.5	0.75	0.0702875	0.97	0.5	0.572571885	1	0	0	2	8	0	0.4583333	0.095238	1.530905218
7	Hall Call Registration	1	1	0.0351438	1	1	0.758785942	1	0	0	2	10	0	0.5416667	0.142857	2.300452609
8	Auto Door Open	1	1	0.0239617	1	1	0.755990415	2	0	0	4	1	0	0.2916667	0	2.047657082
9	Door Open Button	1	1	0.0127796	1	1	0.753194888	3	0	0	3	1	0	0.2916667	0	2.044861555
10	Auto Door Close	1	1	0.0734824	1	1	0.768370607	2	0	0	4	1	1	0.3333333	0	2.10170394
11	Door Close Button	1	1	0.048722	1	1	0.762180511	2	0	0	4	1	1	0.3333333	0	2.095513845
12	Auto Start	1	1	0.0559105	1	1	0.763977636	1	0	0	1	8	0	0.4166667	0.086957	2.180644302
13	Call Button Start	0.5	0.5	0.0295527	0.39	0.5	0.354888179	1	0	0	2	1	1	0.2083333	0	1.063221512
14	Speed Control	1	1	0.0247604	1	1	0.756190096	3	0	0	0	7	0	0.4166667	0	2.172856763
15	Load Weighing Bypass	0.5	0.51	0.0471246	0.53	0.5	0.39678115	0	1	0	2	8	0	0.4583333	0.05	1.355114483
16	Registered Floor Stop	1	1	0.077476	1	1	0.76936901	1	0	0	0	8	0	0.375	0.1	2.14436901
17	Call Data Management	1	1	0.0167732	1	1	0.754193291	9	0	0	0	10	0	0.7916667	0	2.545859957
18	Direction Control	1	1	0.028754	1	1	0.757188498	6	0	0	0	10	0	0.6666667	0	2.423855165
19	Position Control	1	1	0.0191693	1	1	0.754792332	10	0	0	0	13	0	0.9583333	0.043478	2.713125666
20	Car Move	1	1	0.0207668	1	1	0.755191693	3	0	0	5	3	0	0.4583333	0.043478	2.213525027
21	Car Stop	1	1	0.0439297	1	1	0.760982428	3	0	0	1	2	4	0.4166667	0.15	2.177649095
22	Car Button	1	1	0.0159744	1	1	0.75399361	5	0	0	0	2	0	0.2916667	0	2.045660277
23	Hall Button	1	1	0.0391374	1	1	0.759784345	1	0	0	2	1	0	0.1666667	0.095238	1.926451012
24	Weight Sensor	0.5	0.54	0.043131	0.83	0.5	0.478282748	2	0	0	2	2	0	0.25	0	1.228282748
25	Position Sensor	1	1	0.0750799	1	1	0.768769968	1	0	0	0	1	0	0.0833333	0.086957	1.852103301

Table A.4: ECS Features FT, MPPF, DF, IDF, and FRO

ECS Features Sets Options Analysis

In this section we compute *ECS Features Sets Options Prices* as had been done in *Chapter 5*, except that we use *S = X = FSRO(Features Set)*, instead of using *X = FSRO(System Reuse Opportunity)*. The results of these computations and *ECS Features Sets Development Priorities* are shown in *Table A.5*; and *Figure A.8*; shows the relation between *ECS Features Sets Reuse Opportunities* and theirs *Options Prices*.

From these calculations it is appeared that like the computations results when *X = FSRO(System)*, here with *S = X = FSRO(Features Set)*, the *Features Set* with *largest Reuse Opportunity* has the *largest Call Option Price*. Other thing is noticed from results shown in *Table A.5;* that the *difference* between *Call Option Price* and *Put Option Price* has a *positive relationship* with *Features Sets Reuse Opportunity*, i.e. *Features Set* that has the *largest Reuse Opportunity*, also has the *largest difference* between its *Call* and *Put* Prices.

Feature #	Features	Set #	Options	Option Price			Development Priority
			ROFS	Call	Put	Option Value	
8 9 15 16 21	Auto Door Open Door Open Button Load Weighing Bypass Registered Floor Stop Car Stop	6	3.370596912	1.36610003	0.92575930	1.50687223	1st
19 25	Position Control Position Sensor	13	2.781708686	1.12742414	0.76401681	1.24360156	2nd
17	Call Data Management	11	1.886137735	0.76445000	0.51804164	0.84322411	3rd
12 20	Auto Start Car Move	9	1.883678867	0.76345342	0.51736629	0.84212484	4th
1 6 7 23	Passenger Service Anti-Nuisance Hall Call Registration Hall Button	1	1.870575904	0.75814280	0.51376747	0.83626698	5th
18	Direction Control	12	1.86829961	0.75722022	0.51314227	0.83524933	6th
5	Car Call Registration	5	1.864305999	0.75560162	0.51204539	0.83346393	7th
14	Speed Control	10	1.82563454	0.73992811	0.50142399	0.81617531	8th
10	Auto Door Close	7	1.823926163	0.73923570	0.50095477	0.81541156	9th
11	Door Close Button	8	1.817736067	0.73672686	0.49925462	0.81264419	10th
22	Car Button	14	1.802604721	0.73059414	0.49509868	0.80587951	11th
3 13	Fire Service Call Button Start	3	1.138835004	0.46156885	0.31278943	0.50913203	12th
4	Car Call Cancellation	4	1.062215122	0.43051487	0.29174522	0.47487805	13th
24	Weight Sensor	15	1.019949414	0.41338462	0.28013663	0.45598257	14th
2	VIP Service	2	0.992936635	0.40243636	0.27271737	0.44390613	15th

Table A.5: Options Prices and Development Priorities of ECS Features Sets

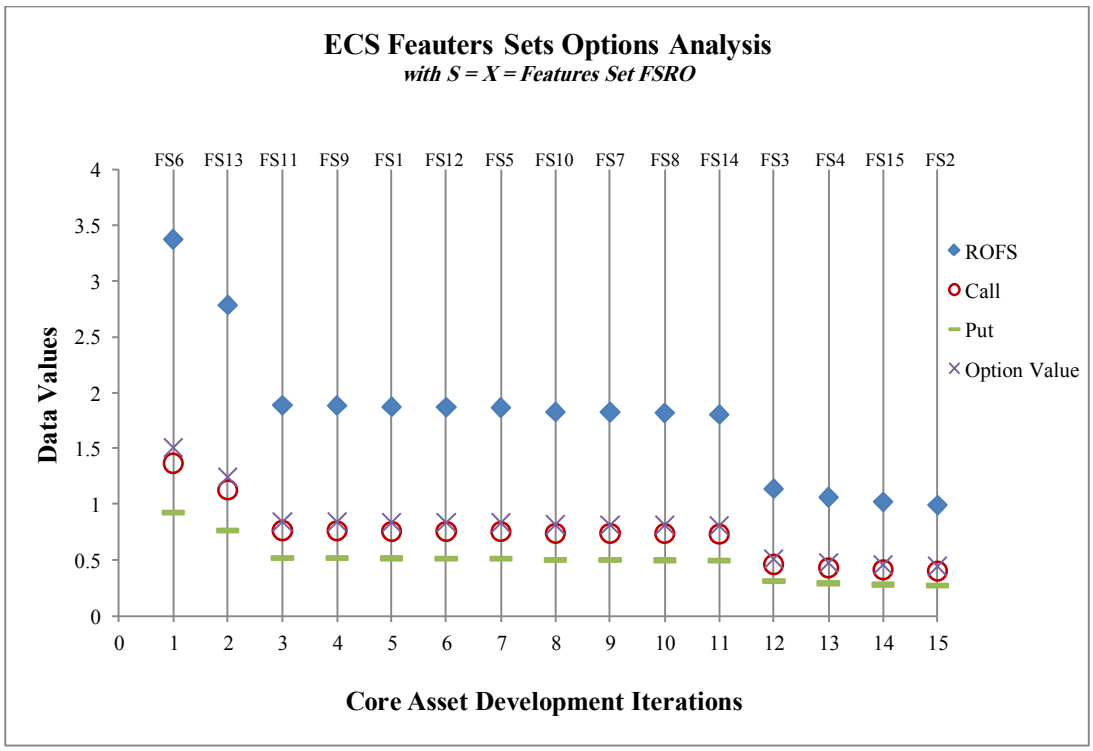

Figure A.8: ECS Features Sets Options Analysis

ECS Features Options Analysis

In this section we compute *ECS Features Options Prices* as had been done in *Chapter 5*, except that we use *S = X = FRO(Feature)*, instead of using *X = FRO(System Reuse Opportunity)*. The results of these computations and *ECS Features Development Priorities* are shown in *Table A.6*; and *Figure A.9*; shows the relation between *ECS features Reuse Opportunities* and theirs *Options Prices*.

From these calculations it is appeared that like the computations results when *X = FRO(System)*, here with *S = X = FRO(Feature)*, the feature with *largest Reuse Opportunity* has the *largest Call Option Price*. Other thing is noticed from results shown in *Table A.6;* that the *difference* between *Call Option Price* and *Put Option Price* has a *positive relationship* with feature *Reuse Opportunity*, i.e. feature that has the *largest Reuse Opportunity*, also has the *largest difference* between its *Call* and *Put Prices*.

Feature #	Features	Options	Option Price			Development Priority
		ROFS	**Call**	**Put**	**Option Value**	
1	Passenger Service	2.7641773	1.449077	0.859278	1.503882	1st
22	Car Button	2.7131257	1.422313	0.843408	1.476107	2nd
20	Car Move	2.54586	1.334627	0.791411	1.385104	3rd
21	Car Stop	2.4238552	1.270668	0.753485	1.318726	4th
9	Door Open Button	2.4198616	1.268574	0.752243	1.316553	5th
3	Fire Service	2.3004526	1.205976	0.715124	1.251587	6th
18	Direction Control	2.213525	1.160406	0.688101	1.204293	7th
17	Call Data Management	2.1806443	1.143169	0.67788	1.186404	8th
14	Speed Control	2.1776491	1.141598	0.676949	1.184774	9th
19	Position Control	2.1728568	1.139086	0.675459	1.182167	10th
13	Call Button Start	2.144369	1.124152	0.666603	1.166668	11th
15	Load Weighing Bypass	2.1017039	1.101785	0.65334	1.143456	12th
16	Registered Floor Stop	2.0955138	1.09854	0.651416	1.140088	13th
10	Auto Door Close	2.0476571	1.073452	0.636539	1.114051	14th
24	Weight Sensor	2.0456603	1.072405	0.635918	1.112964	15th
11	Door Close Button	2.0448616	1.071987	0.63567	1.11253	16th
6	Anti-Nuisance	2.0344968	1.066553	0.632448	1.106891	17th
4	Car Call Cancellation	1.926451	1.009912	0.598861	1.048107	18th
23	Hall Button	1.8521033	0.970936	0.575749	1.007658	19th
5	Car Call Registration	1.82627	0.957393	0.567718	0.993603	20th
2	VIP Service	1.5309052	0.802553	0.4759	0.832906	21st
8	Auto Door Open	1.4788818	0.775281	0.459728	0.804602	22nd
12	Auto Start	1.3551145	0.710397	0.421254	0.737265	23rd
25	Position Sensor	1.2282827	0.643908	0.381827	0.668261	24th
7	Hall Call Registration	1.0632215	0.557377	0.330515	0.578458	25th

Table A.6: Options Prices and Development Priorities of ECS Features

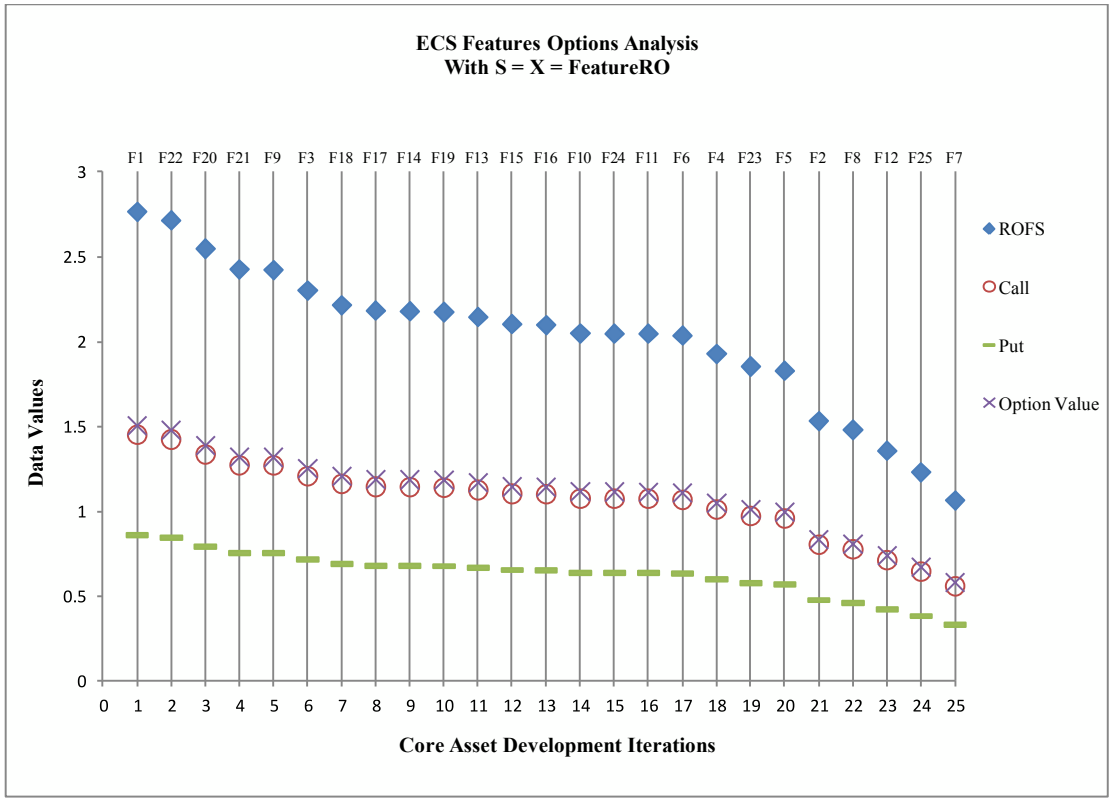

Figure A.9: ECS Features Options Analysis

Appendix B: Scientific Calculator System (SCS)

SCS Features Description

1. Standard: Is a simple calculator mode consists of the Binary Operations; Unique Operations; the ***%*** operation; Sing; Equal; Memory Operations; Clear features; Calculator Display Operations; Decimal Numbers.
2. Scientific: In Scientific mode, Calculator is precise to ***32*** significant digits. In addition to the Standard mode contents (except the ***%*** operation), It consists of trigonometric Numbers mode; Arcs; Scientific Notation; Scientific management Operations; Trigonometric Numbers; Extra Operations; Exponential Operations; Combinatoric Operations (n!); Trigonometric Operations; and Inverse feature (Inv).
3. Programmer: In Programmer mode, Calculator is precise up to ***64*** bits, depending on the word size that can be one of four available sizes. Programmer mode is an integer only mode. Decimal portions are discarded. This mode consists of all Boolean Operations and Binary Operations.
4. Statistics: It displays the Statistics Dialog Box and activates Statistics Operations. When Statistics mode is used, user can enter the data that he wants to calculate statistics for and then perform the calculations. When the data is entered, it's displayed in the dialog box area and the number of values that have been entered is displayed in the calculation area.
5. Display: this service is used to display the entered numbers, calculator operations, operations' results and error displayed result with an expected-Input and/or operation result errors' notifications (in the Calculator Display Box and Dialog Boxes).
6. Clearing: this service used clear operations to delete part or all displayed things in the Calculator Display Box and Dialog Boxes.
7. Systems: there will be four number systems available based on the calculator type selected.
8. Size: number size which appears in the Display Box could be byte (8 bites) to quad byte (64 bites) based on the calculator type selected.
9. Angle: in the scientific calculator there will be three types of angle modes (Degrees, Radians, and Grads).
10. Basic Notation: this is the fundamental numbers notation.
11. Scientific Notation: Numbers larger than 10^{32} are always displayed exponentially. This notation also can be activated when ***F-E***-On is activated. Scientific notation numbers can be activated only when Scientific or Statistics calc is activated.
12. Memory: this service used to store the displayed numbers that can be used for some calculator operations.
13. History: the Calculation History service keeps track of all the calculations that calculator performs in a session. This service is available in both the Standard and the Scientific calculator modes. User can change the values in the calculations in the history. While he is editing the calculation history, the result of the selected calculation is displayed in the result area from the Calculator Display Box. Calculation history is kept separately for Standard and Scientific modes. The history that's displayed depends on the mode that user is using.
14. Binary Operations: which are (+, -, *,and /). Each one of them needs two operators to do its functions.
15. Unique Operations: which are (√, and ***1/x***). These functions can implement with one operator.
16. Exp Functions & Log: the Exponential functions are (x^2 , x^3 , x^y , 10^x , $\sqrt[3]{x}$, and $\sqrt[y]{x}$). Log is to calculate the common (base 10) logarithm.

17. Ln: Calculates natural (base ***e***) logarithm.
18. e Function: To calculate ***e*** raised to the x^{th} power, where x is the current number in Calc Display Box.
19. Combinatoric Operations (***n!***): Calculates the factorial of the displayed number in Calc Display Box.
20. SCTH Functions: these Trigonometric Functions are (***Sin***, ***Cos***, ***Tan***, ***Sinh***, ***Cosh***, and ***Tanh***).
21. SCTHI Functions: the inverse of the Trigonometric Functions are (Sin^{-1} , Cos^{-1} , Tan^{-1} , $Sinh^{-1}$, $Cosh^{-1}$, and $Tanh^{-1}$)
22. Basic Boolean Operation: it consists of (***And***, ***Or***, ***Not***, and ***Xor***).
23. Extra Boolean Operation: these are the left/right rotate and shift operations (***RoL***, ***RoR***, ***Lsh***, and ***Rsh***).
24. Statistics Operations: those are: Average of the values ($\overline{x}$); Average of the square of the values ($\overline{x^2}$); Sum of the values ($\sum x$); Sum of the square of the values ($\sum x^2$); Standard deviation (σ_n); and Standard deviation of population (σ_{n-1}).
25. Percentage Operation (***%***): it can use to calculate the result of any basic operation as a percentage.
26. Mod: Displays the integer modulus, or remainder, of x/y.
27. Int & Dms: ***Int*** displays the integer portion of a decimal value. ***Dms*** converts the displayed number to degree-minute-second format (assuming that the displayed number is in degrees). ***Dms*** can be used only with the decimal number system.
28. Frac & Deg: ***Frac*** used to display the fractional portion of a decimal value. ***Deg*** used to convert the displayed number to degrees (assuming that the displayed number is in degree-minute-second format. ***Deg*** can be used only with the decimal number system.
29. Inputs Display: displays the Inputs operations and operations' parameters in the Calc Display Box.
30. Operations Results Display: displays the operations results in the Calc Display Box.
31. Error messages Display: displays error message in the Calc Display Box if there are an error in the calculation operation, unexpected input value for an operation and/or if the result is large that it cannot displayed in the Calc Display Box. When the error message is displayed the calc functions are disabled until the error message is cleared using ***C*** or ***CE***.
32. Operations History Display: displays the Calculation History in the History Dialog Box.
33. Binary Numbers Display: displays the Binary Numbers in the Binary Dialog Box.
34. Statistics Data Display: displays the entered statistics data in the Statistics Dialog Box.
35. C: Clear function which deletes the current displayed numbers, operations and/or activates Error Clearing function. (Deletes all things that displayed in the Calculator Display Box).
36. CE: Clear Entry Number function which deletes the last displayed number and/ activates Error Clearing function. (Deletes the last entered or resulting number from the Calculator Display Box).
37. Backspace: It deletes the last digit of the displayed number (deletes the last entered digit from the Calculator Screen).
38. CAD: Clear Data which deletes the current displayed numbers from the Statistics Dialog Box. (Deletes all entered data that displayed in the Statistics Dialog Box).
39. Error Clearing: deletes displayed error message and activates Enable Calculator Functions.

40. Memory Store (MS, M+, and M-): ***MS*** stores the displayed number to the memory. ***M+*** used to add the displayed number to any number already in memory. ***M-*** used to subtract the displayed number from any number already in memory. The sum or subtraction result does not display in the Calc Display Box.
41. Memory Recall: ***MR*** recalls the number stored in memory and displays it in the Calc Display Box. The number remains in memory.
42. Memory Clear: ***MC*** clears any number stored in the memory.
43. Decimal: Converts the displayed number to the decimal number system.
44. Binary: Converts the displayed number to the binary number system. The maximum unsigned binary value is an expression of ***64*** bits, all set to ***1***.
45. Octane: Converts the displayed number to the octal number system. The maximum unsigned octal value is an expression of ***64*** bits, all set to ***1***.
46. Hexadecimal: Converts the displayed number to the hexadecimal number system. The maximum unsigned hexadecimal value is ***64*** bits, all set to ***1***.
47. Binary number set: consists of (***0*** and ***1***). This numbers set used when Binary System is activated.
48. Octane number Set: consists of (***0*** … ***7***). This numbers set used when Octane System is activated.
49. Decimal Number Set: consists of (***0*** … ***9***). This numbers set used in the Standard, Scientific and Statistics calc type and when decimal System is activated in the Programmer calc.
50. Decimal Point: Inserts a decimal point.
51. Letter Numbers: Enters the selected letter (***A*** … ***F***) in the value. This type of numbers is available only if hexadecimal mode is activated.
52. Byte Number Set: this set consists of (***0*** ... 2^7 = ***11111111***) in binary system. In this set number contains up 8 bits and displayed in the binary numbers dialog box.
53. Word Number Set: this set consists of (***0*** ... 2^{15} = ***1111111111111111***) in binary system. In this set number contains up ***16*** bits.
54. Dword Number Set: this set consists of (***0*** ... 2^{31} = ***11111111111111111111111111111111***) in binary system. In this set number contains up ***32*** bits.
55. Qword Number Set this set consists of (***0*** ... 2^{63} = ***1111111111111111111111111111111111111111111111111111111111111111***) in binary system. In this set number contains up ***64*** bits.
56. Pi: displays the value of ***pi*** (***3.1415***...).
57. 2Pi: displays ***2*pi*** (***6.28***...). Pi and 2Pi can be used only with the decimal number system.
58. Byte: results can contain up to two digits (***8*** bits). This feature can be selected in the Programmer Calc.
59. Word: results can contain up to four digits (***16*** bits). This feature can be selected in the Programmer Calc.
60. Dword: results can contain up to eight digits (***32*** bits). This feature can be selected in the Programmer Calc.
61. Qword: results can contain up to ***16*** digits (***64*** bits). This feature can be selected in the Programmer Calc.
62. Degrees: Sets trigonometric input for degrees when in decimal mode.
63. Radians: Sets trigonometric input for radians when in decimal mode.

64. Grads: Sets trigonometric input for grads when in decimal mode.
65. Enable Calculator Functions: enable all calc functions.
66. Disable Calculator Functions: disable all calc functions when there are error notifications *except C and CE*.
67. Inverse-On: when Inverse is turned on it activates and shows the inverse functions (***Sin*$^{-1}$** , ***Cos*$^{-1}$** , ***Tan*$^{-1}$** , ***Sinh*$^{-1}$** , ***Cosh*$^{-1}$** , ***Tanh*$^{-1}$** , ***e*^{x}** , ***Frac***, ***Deg***, and ***2Pi***). The functions automatically turn off the inverse function after a calculation is completed.
68. Inverse-Off: when in inverse function is turned off those functions (***Sin*** , ***Cos*** , ***Tan*** , ***Sinh*** , ***Cosh*** , ***Tanh*** , ***Ln*** , ***Dms***, ***Int***, and ***Pi***) will be activated and shown.
69. Equal: Performs any operation on the previous two numbers and to repeat the last implemented operation.
70. Sign: Changes the sign of the displayed number in the Calc Display Box.
71. Arcs: Starts a new level of parentheses using "***(***" and closes the current level of parentheses using "***)***". The current number of levels appears in small box above the ***Int*** or "***)***" button. The maximum number of levels is ***25***.
72. Scientific Notation Editing: which includes ***F-E-On***, ***F-E-Off***, and Exp. ***F-E-On*** turns scientific notation on. ***F-E*** can be used only with the decimal number system. (Displays the current number in exponentially format). ***F-E-Off*** turns scientific notation off. (Displays the current number in basic format). ***Exp*** allows entry of scientific-notation numbers. The exponent is limited to four digits. It can use only decimal digits (keys ***0*** through ***9***) in the exponent. Exp can be used only with the decimal number system.
73. Add: Enters the displayed number in Calc Display Box to the Statistics dialog box. This function is available only if Statistics Calc is activated.
74. Result Foundation: analyzes the input displaying string in the Display box using Parsing and Number Conversion features to calculate the expressions results.
75. Unexpected Input Handling: is used to prevent the square root function from taking a negative value as input. Also, it used to prevent divide by zero. In these cases this feature activates Error Notification.
76. Error Notification: notifies the errors in calculations operations.
77. Parsing: used to extract numbers from an input string for result and conversion processes.
78. Number Conversion: used to convert the extracting strings to numbers based on the system number selected.
79. Buttons: Calc Buttons.
80. Systems Selection Buttons: used to select the wanted number system. It is available in the Programmer Calc type.
81. Size Selection Buttons: used to select the wanted number size. It is available in the Programmer Calc type.
82. Display Box: This used to display inputs operations, operations' parameters, and their results and/or error messages.
83. History Dialog Box: This used to display operations history for Standard and Scientific calc.
84. Statistics Dialog Box: This used to display the entered data when Statistics calc is activated.
85. Binary Numbers Dialog Box: This used to display and enter the binary numbers when Programmer calc is activated.
86. Menu: this used to select Calc type and to activate or deactivate operations history.

SCS Features Marketing Product Plan Attributes

	Features	*FM Factor*	*MPP Factor*			
		Feature Type	*Need Assessment*	*Price Range*	*Feature coverage*	*Feature Binding*
1	Standard	Common	H	H|L	A	B
2	Scientific	Optional	H|L	H|L	A|S	I
3	Programmer	Optional	H|L	H|L	A|S	I
4	Statistics	Optional	H|L	H|L	A|S	I
5	Display	Common	H	H|L	A	B
6	Clearing	Common	H	H|L	A	B
7	Systems	Optional	H|L	H|L	A|S	I
8	Size	Common	H	H|L	A	B
9	Angle	Optional	H|L	H|L	A|S	I
10	Basic Notation	Common	H	H|L	A	B
11	Scientific Notation	Optional	H|L	H|L	A|S	I
12	Memory	Optional	H|L	H|L	A|S	I
13	History	Optional	H|L	H|L	A|S	I
14	Binary Operations	Common	H	H|L	A	B
15	Unique Operations	Optional	H|L	H|L	A|S	I
16	Exp Functions & Log	Common	H	H|L	A	B
17	Ln	Optional	H|L	H|L	A|S	I
18	e Function	Optional	H|L	H|L	A|S	I
19	n!	Optional	H|L	H|L	A|S	I
20	SCTH Functions	Common	H	H|L	A	B
21	SCTHI Functions	Optional	H|L	H|L	A|S	I
22	Basic Boolean Operation	Common	H	H|L	A	B
23	Extra Boolean Operation	Optional	H|L	H|L	A|S	I
24	Statistics Operations	Optional	H|L	H|L	A|S	I
25	Percentage (%)	Common	H	H|L	A	B
26	Mod	Common	H	H|L	A	B
27	Int & Dms	Optional	H|L	H|L	A|S	I
28	Frac & Deg	Optional	H|L	H|L	A|S	I
29	Inputs Display	Common	H	H|L	A	B
30	Operations Results Display	Common	H	H|L	A	B
31	Error messages Display	Optional	H|L	H|L	A|S	I
32	Operations History Display	Optional	H|L	H|L	A|S	I
33	Binary Numbers Display	Optional	H|L	H|L	A|S	I
34	Statistics Data Display	Optional	H|L	H|L	A|S	I
35	C	Common	H	H|L	A	B
36	CE	Optional	H|L	H|L	A|S	I
37	Backspace	Optional	H|L	H|L	A|S	I
38	CAD	Optional	H|L	H|L	A|S	I
39	Error Clearing	Common	H	H|L	A	B
40	Memory Store	Common	H	H|L	A	B
41	Memory Recall	Common	H	H|L	A	B
42	Memory Clear	Common	H	H|L	A	B

Table B.1: SCS Features MPP Attributes (features 1 to 42)

SCS Features Marketing Product Plan Attributes (continue)

	Features	*FM Factor*	*MPP Factor*			
		Feature Type	*Need Assessment*	*Price Range*	*Feature coverage*	*Feature Binding*
43	Decimal	Common	H	H|L	A	B
44	Binary	Optional	H|L	H|L	A|S	I
45	Octane	Optional	H|L	H|L	A|S	I
46	Hexadecimal	Optional	H|L	H|L	A|S	I
47	Binary number set	Optional	H|L	H|L	A|S	I
48	Octane number Set	Optional	H|L	H|L	A|S	I
49	Decimal Number Set	Common	H	H|L	A	B
50	Decimal Point	Common	H	H|L	A	B
51	Letter Numbers	Optional	H|L	H|L	A|S	I
52	Byte Number Set	Common	H	H|L	A	B
53	Word Number Set	Common	H	H|L	A	B
54	Dword Number Set	Optional	H|L	H|L	A|S	I
55	Qword Number Set	Optional	H|L	H|L	A|S	I
56	Pi	Common	H	H|L	A	B
57	2Pi	Optional	H|L	H|L	A|S	I
58	Byte	Common	H	H|L	A	B
59	Word	Common	H	H|L	A	B
60	Dword	Optional	H|L	H|L	A|S	I
61	Qword	Optional	H|L	H|L	A|S	I
62	Degrees	Common	H	H|L	A	B
63	Radians	Optional	H|L	H|L	A|S	I
64	Grads	Optional	H|L	H|L	A|S	I
65	Enable Calculator Functions	Common	H	H|L	A	B
66	Disable Calculator Functions	Optional	H|L	H|L	A|S	I
67	Inverse-On	Optional	H|L	H|L	A|S	I
68	Inverse--Off	Common	H	H|L	A	B
69	Equal	Common	H	H|L	A	B
70	Sign	Common	H	H|L	A	B
71	Arcs	Optional	H|L	H|L	A|S	I
72	Scientific Notation Editing	Optional	H|L	H|L	A|S	I
73	Add	Common	H	H|L	A	B
74	Result Foundation	Common	H	H|L	A	B
75	Unexpected Input Handling	Optional	H|L	H|L	A|S	I
76	Error Notification	Common	H	H|L	A	B
77	Parsing	Common	H	H|L	A	B
78	Number Conversion	Common	H	H|L	A	B
79	Calc Buttons	Common	H	H|L	A	B
80	Systems Selection Buttons	Optional	H|L	H|L	A|S	I
81	Size Selection Buttons	Optional	H|L	H|L	A|S	I
82	Display Box	Common	H	H|L	A	B
83	History Dialog Box	Optional	H|L	H|L	A|S	I
84	Statistics Dialog Box	Optional	H|L	H|L	A|S	I
85	Binary Numbers Dialog Box	Optional	H|L	H|L	A|S	I
86	Menu	Optional	H|L	H|L	A|S	I

Table B.2: SCS Features MPP Attributes (features 43 to 86)

SCS features Dependencies information Adjustment

As we do for the previous case study we adjust the information of *SCS* features relations dependencies shown in *Table 5.17* to *Table 5.25*; to be appropriate for the *Weighting Process*. The adjustment process results are shown in *Table B.3*; to *Table B.10*.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
1	Standard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Scientific	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Programmer	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Statistics	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Display	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Clearing	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Systems	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Size	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Angle	E	US	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Basic Notation	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Scientific Notation	US	US	E	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Memory	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	History	US	US	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Binary Operations	US	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Unique Operations	US	US	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Exp Functions & Log	E	US	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Ln	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	e Function	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	n!	E	US	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	SCTH Functions	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	SCTHI Functions	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	Basic Boolean Operation	E	E	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Extra Boolean Operation	E	E	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Statistics Operations	E	E	E	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Percentage (%)	US	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Mod	E	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	Int & Dms	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	Frac & Deg	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.3: SCS Features Dependencies after Adjustment Transferring and Removing Processes

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
1	Standard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Scientific	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Programmer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Statistics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Clearing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
8	Size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
9	Angle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
10	Basic Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
11	Scientific Notation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
12	Memory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	History	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Binary Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
15	Unique Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
16	Exp Functions & Log	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
17	Ln	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
18	e Function	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
19	n!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
20	SCTH Functions	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
21	SCTHI Functions	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
22	Basic Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
23	Extra Boolean Operation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
24	Statistics Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
25	Percentage (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
26	Mod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
27	Int & Dms	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
28	Frac & Deg	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-

Table B.4: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
29	Inputs Display	-	-	-	-	S	-	-	-	-	-	-	-	-	U	U	U	U	U	U	U	U	U	U	-	U	U	U	U
30	Operations Results Display	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Error messages Display	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Operations History Display	UM	UM	E	E	S	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	Binary Numbers Display	E	E	U	E	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	Statistics Data Display	E	E	E	U	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	-	-	-	-
35	C	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	CE	-	-	-	E	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	Backspace	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	CAD	E	E	E	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	Error Clearing	-	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Memory Store	U	U	U	U	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Memory Recall	U	U	U	U	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	Memory Clear	U	U	U	U	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	Decimal	U	U	U	U	-	-	S	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	Binary	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	Octane	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	Hexadecimal	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	Binary number set	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	Octane number Set	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	Decimal Number Set	U	U	U	U	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	Decimal Point	U	U	E	U	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	Letter Numbers	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	Byte Number Set	E	E	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	Word Number Set	E	E	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	Dword Number Set	E	E	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	Qword Number Set	E	E	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	Pi	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	2Pi	E	U	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.5: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
29	Inputs Display	-	-	-	U	-	-	M	M	M	-	-	U	-	-	M	M	M	M	U	U	U	U	U	U	U	U	U	U	U
30	Operations Results Display	-	-	-	U	-	-	M	M	-	-	-	-	U	U	M	M	M	M	-	-	-	-	-	-	-	-	-	-	-
31	Error messages Display	-	-	-	-	-	-	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Operations History Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	Binary Numbers Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	U	-	-
34	Statistics Data Display	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	C	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	CE	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	Backspace	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	CAD	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	Error Clearing	-	-	E	-	-	-	UC	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Memory Store	-	-	-	-	-	-	-	-	-	-	-	-	U	EM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Memory Recall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	Memory Clear	-	-	-	-	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	Decimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	Binary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	Octane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-
46	Hexadecimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-
47	Binary number set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	UC	E	E	-	-	-	-	-	-	-	-	-	-	-
48	Octane number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	UC	E	-	-	-	-	-	-	-	-	-	-	-
49	Decimal Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	E	E	UC	-	-	-	-	-	-	-	-	-	-	-
50	Decimal Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	E	E	E	-	-	-	-	-	-	-	-	-	-	-
51	Letter Numbers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	E	UC	-	-	-	-	-	-	-	-	-	-	-
52	Byte Number Set	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	Word Number Set	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	Dword Number Set	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	Qword Number Set	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	Pi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	2Pi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.6: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
29	Inputs Display	M	M	M	M	M	M	M	-	-	-	-	-	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-
30	Operations Results Display	M	M	M	M	M	M	M	-	-	-	-	-	-	-	-	-	UQ	-	-	-	-	-	-	-	-	-	-	-	-
31	Error messages Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	UQ	-	-	-	-	-	-	-	-	-	-
32	Operations History Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	Binary Numbers Display	M	M	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	Statistics Data Display	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-
35	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	CE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	Backspace	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	CAD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	Error Clearing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Memory Store	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Memory Recall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	Memory Clear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	Decimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-
44	Binary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-
45	Octane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-
46	Hexadecimal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-
47	Binary number set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
48	Octane number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
49	Decimal Number Set	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
50	Decimal Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
51	Letter Numbers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
52	Byte Number Set	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
53	Word Number Set	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
54	Dword Number Set	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
55	Qword Number Set	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
56	Pi	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
57	2Pi	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-

Table B.7: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Feature	Standard	Scientific	Programmer	Statistics	Display	Clearing	Systems	Size	Angle	Basic Notation	Scientific Notation	Memory	History	Binary Operations	Unique Operations	Exp Functions & Log	Ln	e Function	n!	SCTH Functions	SCTHI Functions	Basic Boolean Operation	Extra Boolean Operation	Statistics Operations	Percentage (%)	Mod	Int & Dms	Frac & Deg
58	Byte	U	U	U	U	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	Word	U	U	U	U	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	Dword	U	U	U	U	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61	Qword	E	U	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	Degrees	-	-	-	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	Radians	-	-	-	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	Grads	-	-	-	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	Enable Calculator Functions	S	S	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	Disable Calculator Functions	S	S	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Inverse-On	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	-	-	E	-	-	-	-	-	-	E	-
68	Inverse--Off	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	EQ	-	-	EQ	-	-	-	-	-	-	EQ
69	Equal	US	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	Sign	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71	Arcs	E	US	US	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	Scientific Notation Editing	E	US	E	US	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	Add	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74	Result Foundation	US	US	US	US	-	-	-	-	-	-	-	-	-	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
75	Unexpected Input Handling	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76	Error Notification	US	US	US	US	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	Parsing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78	Number Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	Calc Buttons	S	S	S	S	-	-	-	-	-	-	-	-	-	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC	UC
80	System Selection Buttons	E	E	U	E	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	Size Selection Buttons	E	E	U	E	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Display Box	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	History Dialog Box	-	-	E	E	S	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84	Statistics Dialog Box	E	E	E	U	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85	Binary Numbers Dialog Box	E	E	-	E	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86	Menu	US	US	US	US	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.8: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	Feature	Inputs Display	Operations Results Display	Error messages Display	Operations History Display	Binary Numbers Display	Statistics Data Display	C	CE	Backspace	CAD	Error Clearing	Memory Store	Memory Recall	Memory Clear	Decimal	Binary	Octane	Hexadecimal	Binary number set	Octane number Set	Decimal Number Set	Decimal Point	Letter Numbers	Byte Number Set	Word Number Set	Dword Number Set	Qword Number Set	Pi	2Pi
58	Byte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	E	E	E	-	-
59	Word	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	C	E	E	-	-
60	Dword	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	C	E	-	-
61	Qword	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	E	C	-	-
62	Degrees	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	Radians	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	Grads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	Enable Calculator Functions	-	-	-	-	-	-	-	-	-	-	UQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	Disable Calculator Functions	-	-	UC	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Inverse-On	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	-
68	Inverse--Off	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	EQ
69	Equal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	Sign	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71	Arcs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	Scientific Notation Editing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	Add	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74	Result Foundation	C	-	-	-	-	C	-	-	-	-	-	-	-	-	M	M	M	M	-	-	-	-	-	-	-	-	-	-	-
75	Unexpected Input Handling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76	Error Notification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	Parsing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78	Number Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	Calc Buttons	UC	-	-	-	-	-	UC	UC	UC	UC	-	UC	UC	UC	-	-	-	-	UC	UC	UC	UC	UC	-	-	-	-	UC	UC
80	System Selection Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	UC	UC	UC	-	-	-	-	-	-	-	-	-	-	-
81	Size Selection Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Display Box	UC	UC	UC	-	-	-	UC	UC	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	History Dialog Box	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84	Statistics Dialog Box	-	-	-	-	-	UC	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85	Binary Numbers Dialog Box	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	UC	UC	UC	-	-
86	Menu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.9: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Feature	Byte	Word	Dword	Qword	Degrees	Radians	Grads	Enable Calc Functions	Disable Calc Functions	Inverse-On	Inverse--Off	Equal	Sign	Arcs	Scientific Notation Editing	Add	Result Foundation	Unexpected Input Handling	Error Notification	Parsing	Number Conversion	Calc Buttons	System Selection Buttons	Size Selection Buttons	Display Box	History Dialog Box	Statistics Dialog Box	Binary Numbers Dialog Box	Menu
58	Byte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	Word	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	Dword	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61	Qword	E	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	Degrees	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	Radians	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	Grads	-	-	-	-	E	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	Enable Calculator Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	Disable Calculator Functions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Inverse-On	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Inverse--Off	-	-	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	Equal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	Sign	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
71	Arcs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
72	Scientific Notation Editing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	Add	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74	Result Foundation	M	M	M	M	M	M	M	-	-	-	-	Q	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-
75	Unexpected Input Handling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
76	Error Notification	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-	E	Q	-	-	-	-	-	-	-	-	-	-	-
77	Parsing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-
78	Number Conversion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	US	-	-	-	-	-	-	-	-	-	-	-	-
79	Calc Buttons	-	-	-	-	UC	UC	UC	-	-	UC	UC	UC	UC	UC	UC	UC	-	-	-	-	-	-	-	-	-	-	-	-	-
80	System Selection Buttons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	Size Selection Buttons	UC	UC	UC	UC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Display Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83	History Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84	Statistics Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	UC	-	-	-	-	-	-	-	-	-	-	-	-	-
85	Binary Numbers Dialog Box	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86	Menu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.10: SCS Features Dependencies after Adjustment Transferring and Removing Processes (cont…)

Feature #	Features	Dependency Factors							Feature #	Features	Dependency Factors						
		Usage	Modification	Subordinate-Activation	Exclusive-Activation	Concurrent-Activation	Sequential-Activation	Total			Usage	Modification	Subordinate-Activation	Exclusive-Activation	Concurrent-Activation	Sequential-Activation	Total
1	Standard	0	0	0	38	0	0	38	44	Binary	2	0	1	10	2	0	15
2	Scientific	0	0	0	24	0	0	24	45	Octane	2	0	1	10	2	0	15
3	Programmer	0	0	0	26	0	0	26	46	Hexadecimal	2	0	1	9	3	0	15
4	Statistics	0	0	0	41	0	0	41	47	Binary No. Set	3	0	1	6	2	0	12
5	Display	4	0	4	0	0	0	8	48	Octane No. Set	3	0	1	6	2	0	12
6	Clearing	4	0	4	0	0	0	8	49	Decimal No. Set	7	0	1	2	3	0	13
7	Systems	5	0	4	0	0	0	9	50	Decimal Point	5	0	1	4	2	0	12
8	Size	5	0	4	0	0	0	9	51	Letter Numbers	3	0	1	6	2	0	12
9	Angle	2	0	1	3	0	0	6	52	Byte No. Set	3	0	1	6	3	0	13
10	Basic Notation	5	0	4	0	0	0	9	53	Word No. Set	3	0	1	6	3	0	13
11	Scientific Notation	4	0	3	1	1	0	9	54	Dword No. Set	3	0	1	6	3	0	13
12	Memory	4	0	4	0	0	0	8	55	Qword No. Set	3	0	1	6	3	0	13
13	History	2	0	2	2	1	0	7	56	Pi	2	0	1	4	1	0	8
14	Binary Operations	4	0	3	1	2	0	10	57	2Pi	2	0	1	4	1	0	8
15	Unique Operations	3	0	2	2	2	0	9	58	Byte	4	0	1	6	2	0	13
16	Exp Functions & Log	2	0	1	3	2	0	8	59	Word	4	0	1	6	2	0	13
17	Ln	2	0	1	4	2	0	9	60	Dword	4	0	1	6	2	0	13
18	e Function	2	0	1	4	2	0	9	61	Qword	2	0	1	8	2	0	13
19	n!	2	0	1	3	2	0	8	62	Degrees	1	0	1	2	1	0	5
20	SCTH Functions	2	0	1	4	2	0	9	63	Radians	1	0	1	2	1	0	5
21	SCTHI Functions	2	0	1	4	2	0	9	64	Grads	1	0	1	2	1	0	5
22	Basic Boolean Op.	2	0	1	3	2	0	8	65	Enable Calc Fun.	1	0	4	1	0	1	7
23	Extra Boolean Op.	2	0	1	3	2	0	8	66	Disable Calc Fun.	1	0	4	1	1	0	7
24	Statistics Operations	2	0	1	3	3	0	9	67	Inverse-On	1	0	1	5	1	0	8
25	Percentage (%)	2	0	1	3	2	0	8	68	Inverse--Off	1	0	1	5	1	4	12
26	Mod	3	0	2	2	2	0	9	69	Equal	3	0	3	1	1	0	8
27	Int & Dms	2	0	1	4	2	0	9	70	Sign	5	0	4	0	1	0	10
28	Frac & Deg	2	0	1	4	2	0	9	71	Arcs	3	0	2	2	1	0	8
29	Inputs display	32	14	1	3	3	0	53	72	Scientific Not. Editing	2	0	2	2	2	0	8
30	Op. Results Display	4	13	1	2	1	1	22	73	Add	1	0	1	0	3	0	5
31	Error messages Display	2	2	1	3	2	1	11	74	Result Foundation	4	12	4	1	17	1	39
32	History Display	3	2	1	2	1	0	9	75	Unexpected Input Handling	1	0	2	0	0	0	3
33	Binary No. Display	5	4	1	3	5	0	18	76	Error Notification	4	0	4	2	0	1	11
34	Statistics Data Display	4	1	1	4	4	0	14	77	Parsing	1	0	1	0	0	0	2
35	C	1	0	1	3	3	0	8	78	Number Conversion	1	0	1	0	0	0	2
36	CE	1	0	1	4	3	0	9	79	Calc Buttons	40	0	4	0	40	0	84
37	Backspace	1	0	1	1	2	0	5	80	System Selection Buttons	5	0	1	3	4	0	13
38	CAD	1	0	1	4	2	0	8	81	Size Selection Buttons	5	0	1	3	4	0	13
39	Error Clearing	2	0	1	2	2	0	7	82	Display Box	6	0	1	0	6	0	13
40	Memory Store	5	1	1	1	1	0	9	83	History Dialog Box	2	0	1	2	2	0	7
41	Memory Recall	4	0	1	0	1	0	6	84	Statistics Dialog Box	4	0	1	3	3	0	11
42	Memory Clear	4	0	1	1	1	0	7	85	Binary No. Dialog Box	5	0	1	3	5	0	14
43	Decimal	7	0	1	6	3	0	17	86	Menu	5	0	4	0	0	0	9

Table B.11: SCS Features Dependencies Values after Adjustment processes

SCS Features and Features Relations Weights

*Vertices	32 "F32"	64 "F64"	1 10 -8	1 49 -5	2 7 -8	2 46 -4	2 86 -8	3 42 -5	3 84 -4	4 42 -5	4 83 -4		53 74 -5	60 74 -2
86	33 "F33"	65 "F65"	1 11 -8	1 50 -5	2 8 -8	2 47 -4	3 4 -4	3 43 -5	3 86 -8	4 43 -5	4 84 -5		53 85 -9	60 81 -9
1 "F1"	34 "F34"	66 "F66"	1 12 -8	1 51 -4	2 9 -2	2 48 -4	3 5 -8	3 44 -5	4 5 -8	4 44 -4	4 85 -4		54 58 -4	61 74 -2
2 "F2"	35 "F35"	67 "F67"	1 13 -8	1 52 -4	2 10 -8	2 49 -5	3 6 -8	3 45 -5	4 6 -8	4 45 -4	4 86 -8		54 59 -4	61 81 -9
3 "F3"	36 "F36"	68 "F68"	1 14 -8	1 53 -4	2 11 -8	2 50 -5	3 7 -8	3 46 -5	4 7 -8	4 46 -4	5 29 3		54 60 -9	62 63 -4
4 "F4"	37 "F37"	69 "F69"	1 15 -8	1 54 -4	2 12 -8	2 51 -4	3 8 -8	3 47 -5	4 8 -8	4 47 -4	5 30 3		54 61 -4	62 64 -4
5 "F5"	38 "F38"	70 "F70"	1 16 -4	1 55 -4	2 13 -8	2 52 -4	3 9 -4	3 48 -5	4 9 -4	4 48 -4	5 31 3		54 74 -5	62 74 -2
6 "F6"	39 "F39"	71 "F71"	1 17 -4	1 56 -4	2 14 -8	2 53 -4	3 10 -8	3 49 -5	4 10 -8	4 49 -5	5 32 3		54 85 -9	62 79 -9
7 "F7"	40 "F40"	72 "F72"	1 18 -4	1 57 -4	2 15 -8	2 54 -4	3 11 -4	3 50 -4	4 11 -8	4 50 -5	5 33 3		55 58 -4	63 64 -4
8 "F8"	41 "F41"	73 "F73"	1 19 -4	1 58 -5	2 16 -2	2 55 -4	3 12 -8	3 51 -5	4 12 -8	4 51 -4	5 34 3		55 59 -4	63 74 -2
9 "F9"	42 "F42"	74 "F74"	1 20 -4	1 59 -5	2 17 -5	2 56 -5	3 13 -4	3 52 -5	4 13 -4	4 52 -4	5 82 3		55 60 -4	63 79 -9
10 "F10"	43 "F43"	75 "F75"	1 21 -4	1 60 -5	2 18 -5	2 57 -5	3 14 -8	3 53 -5	4 14 -4	4 53 -4	5 83 3		55 61 -9	64 74 -2
11 "F11"	44 "F44"	76 "F76"	1 22 -4	1 61 -4	2 19 -2	2 58 -5	3 15 -4	3 54 -5	4 15 -4	4 54 -4	5 84 3		55 74 -5	64 79 -9
12 "F12"	45 "F45"	77 "F77"	1 23 -4	1 65 -3	2 20 -5	2 59 -5	3 16 -4	3 55 -5	4 16 -4	4 55 -4	5 85 3		55 85 -9	65 76 -4
13 "F13"	46 "F46"	78 "F78"	1 24 -4	1 66 -3	2 21 -5	2 60 -5	3 17 -4	3 56 -4	4 17 -4	4 56 -4	6 35 8		56 67 -4	67 68 -4
14 "F14"	47 "F47"	79 "F79"	1 25 -2	1 69 -8	2 22 -4	2 61 -5	3 18 -4	3 57 -4	4 18 -4	4 57 -4	6 36 8		56 68 3	67 79 -9
15 "F15"	48 "F48"	80 "F80"	1 26 -4	1 70 -8	2 23 -4	2 65 -3	3 19 -4	3 58 -5	4 19 -4	4 58 -5	6 37 8	...	56 74 -5	68 79 -9
16 "F16"	49 "F49"	81 "F81"	1 27 -4	1 71 -4	2 24 -4	2 66 -3	3 20 -4	3 59 -5	4 20 -4	4 59 -5	6 38 8		56 79 -9	69 74 1
17 "F17"	50 "F50"	82 "F82"	1 28 -4	1 72 -4	2 25 -4	2 67 8	3 21 -4	3 60 -5	4 21 -4	4 60 -5	6 39 3		57 67 3	69 79 -9
18 "F18"	51 "F51"	83 "F83"	1 32 -7	1 74 -8	2 26 -8	2 68 8	3 22 -2	3 61 -5	4 22 -4	4 61 -4	7 43 3		57 68 -5	70 74 -5
19 "F19"	52 "F52"	84 "F84"	1 33 -4	1 75 -3	2 27 -5	2 69 -8	3 23 -2	3 65 -3	4 23 -4	4 65 -3	7 44 3		57 74 -5	70 79 -9
20 "F20"	53 "F53"	85 "F85"	1 34 -4	1 76 -8	2 28 -5	2 70 -8	3 24 -4	3 66 -3	4 24 -2	4 66 -3	7 45 3		57 79 -9	71 74 -5
21 "F21"	54 "F54"	86 "F86"	1 38 -4	1 79 -3	2 32 -7	2 71 -8	3 25 -4	3 69 -8	4 25 -4	4 69 -4	7 46 3		58 59 -4	71 79 -9
22 "F22"	55 "F55"	*Edges	1 40 -5	1 80 -4	2 33 -4	2 72 -8	3 26 -8	3 70 -8	4 26 -4	4 70 -8	7 47 3		58 60 -4	72 79 -9
23 "F23"	56 "F56"	1 2 -4	1 41 -5	1 81 -4	2 34 -4	2 74 -8	3 27 -4	3 71 -8	4 27 -4	4 71 -4	7 48 3		58 61 -4	73 79 -9
24 "F24"	57 "F57"	1 3 -4	1 42 -5	1 84 -4	2 38 -4	2 75 -3	3 28 -4	3 72 -4	4 28 -4	4 72 -8	7 49 3		58 74 -2	73 84 -9
25 "F25"	58 "F58"	1 4 -4	1 43 -5	1 85 -4	2 40 -5	2 76 -8	3 32 -4	3 74 -8	4 32 -4	4 73 8	7 50 3		58 81 -9	74 75 5
26 "F26"	59 "F59"	1 5 -8	1 44 -4	1 86 -8	2 41 -5	2 79 -3	3 33 -5	3 76 -8	4 33 -4	4 74 -8	7 51 3		59 60 -4	74 76 -6
27 "F27"	60 "F60"	1 6 -8	1 45 -4	2 3 -4	2 42 -5	2 80 -4	3 34 -4	3 79 -3	4 34 -5	4 76 -8	7 74 -5		59 61 -4	74 77 8
28 "F28"	61 "F61"	1 7 -8	1 46 -4	2 4 -4	2 43 -5	2 81 -4	3 38 -4	3 80 -5	4 36 -4	4 79 -3	7 80 3		59 74 -2	74 78 8
29 "F29"	62 "F62"	1 8 -8	1 47 -4	2 5 -8	2 44 -4	2 84 -4	3 40 -5	3 81 -5	4 40 -5	4 80 -4	8 52 3		59 81 -9	75 76 1
30 "F30"	63 "F63"	1 9 -4	1 48 -4	2 6 -8	2 45 -4	2 85 -4	3 41 -5	3 83 -4	4 41 -5	4 81 -4	8 53 3		60 61 -4	

Figure B.1: Input Text file for Pajek of SCS Features and Features Relations Weights

(The original text file is one column contains 675 lines)

Pajek SCS Features Classifications

SCS Features Classification (Pajek Result Graph at Number of Clusters = 1)

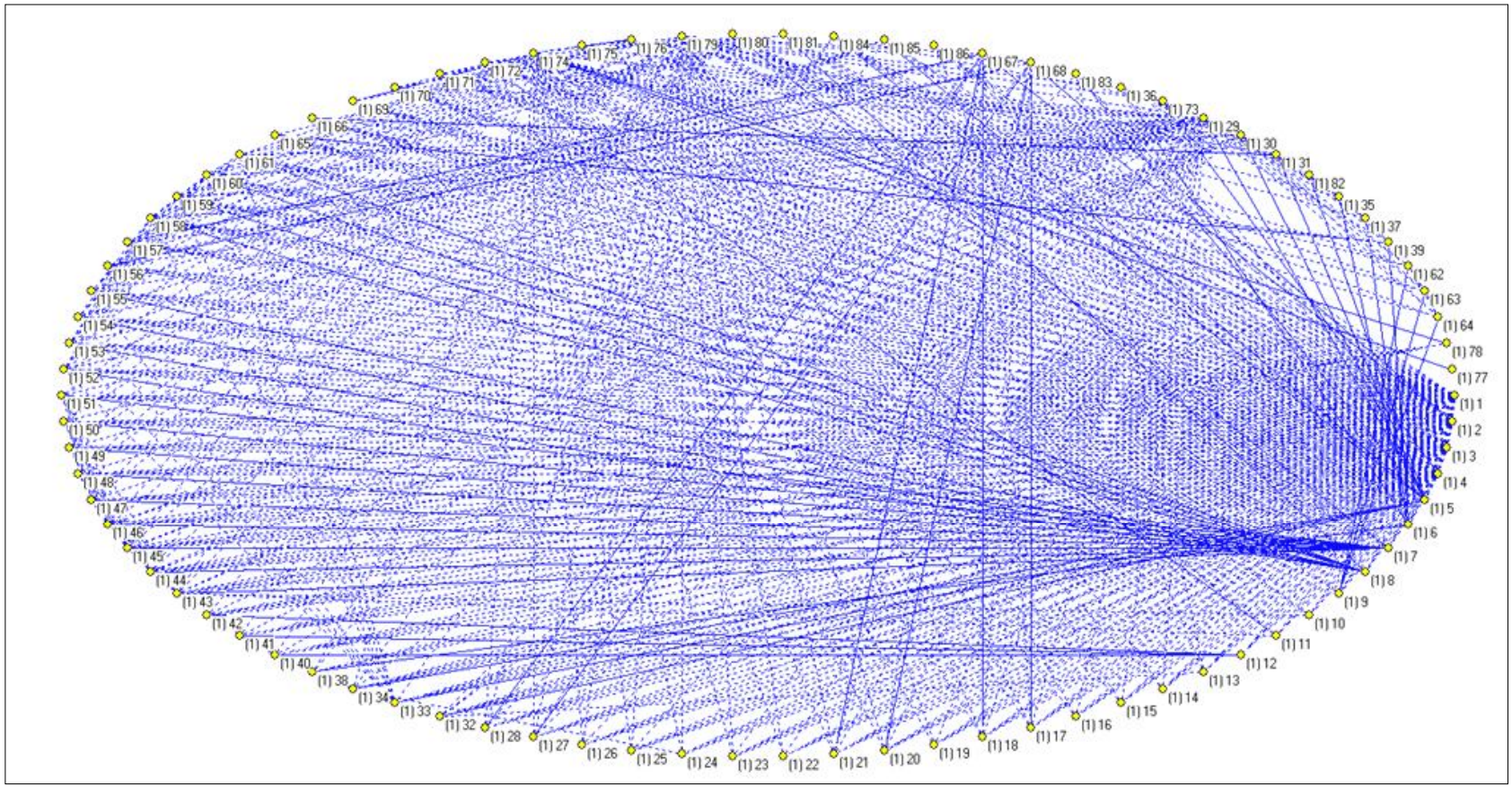

Figure B.2: SCS Features Classification (Pajek Result at Number of clusters = 1)

SCS Features Classification (Pajek Result Report at Number of Clusters = 1)

Reading Network --- G:\Thesis\Thesis Experiments\SCS\SCS Pajek results\SCS-pacjek-data.net

----

Working...
675 lines read.
Time spent: 0:00:00

Signed graphs: positive diagonal blocks, negative off-diagonal blocks

----

Working...
Number of clusters: 1, alpha: 0.500, min size of clusters: 1

------- Starting partition -------

Errors: 2889.00 Lines

-8.00 :	1-69
-4.00 :	1-2
-4.00 :	1-3
-4.00 :	1-4
-8.00 :	1-5
-8.00 :	1-6
-8.00 :	1-7
-8.00 :	1-8
-4.00 :	1-9
-8.00 :	1-10
-8.00 :	1-11
-8.00 :	1-12
-8.00 :	1-13
-8.00 :	1-14
-8.00 :	1-15
-4.00 :	1-16
-4.00 :	1-20
-4.00 :	1-21
-4.00 :	1-22
-4.00 :	1-23
-4.00 :	1-24
-2.00 :	1-25
-4.00 :	1-26
-4.00 :	1-27
-4.00 :	1-28
-7.00 :	1-29
-4.00 :	1-30
-4.00 :	1-31
-4.00 :	1-32
-5.00 :	1-33
-5.00 :	1-34
-5.00 :	1-35
-5.00 :	1-36
-4.00 :	1-37
-4.00 :	1-38
-4.00 :	1-39
-4.00 :	1-40
-4.00 :	1-41
-5.00 :	1-42
-5.00 :	1-43
-4.00 :	1-44
-4.00 :	1-45
-4.00 :	1-46
-4.00 :	1-47
-4.00 :	1-48
-4.00 :	1-49
-5.00 :	1-51
-5.00 :	1-52
-5.00 :	1-53
-4.00 :	1-54
-3.00 :	1-55
-3.00 :	1-56
-8.00 :	1-57
-8.00 :	1-58
-4.00 :	1-59
-4.00 :	1-60
-8.00 :	1-61
-3.00 :	1-62
-8.00 :	1-63
-3.00 :	1-64
-4.00 :	1-65
-4.00 :	1-66
-4.00 :	1-67
-4.00 :	1-68
-8.00 :	2-69
-4.00 :	2-3
-4.00 :	2-4
-8.00 :	2-5
-8.00 :	2-6
-8.00 :	2-7
-8.00 :	2-8
-2.00 :	2-9
-8.00 :	2-10
-8.00 :	2-11
-8.00 :	2-12
-8.00 :	2-13
-8.00 :	2-15
-2.00 :	2-16
-5.00 :	2-17
-5.00 :	2-18
-2.00 :	2-19
-5.00 :	2-20
-5.00 :	2-21
-4.00 :	2-22
-4.00 :	2-23
-4.00 :	2-24
-4.00 :	2-25
-8.00 :	2-26
-5.00 :	2-27
-5.00 :	2-28
-7.00 :	2-29
-4.00 :	2-30
-4.00 :	2-31
-4.00 :	2-32
-5.00 :	2-33
-5.00 :	2-34
-5.00 :	2-35
-5.00 :	2-36
-4.00 :	2-37
-4.00 :	2-38
-4.00 :	2-39
-4.00 :	2-40
-4.00 :	2-41
-5.00 :	2-42
-5.00 :	2-43
-4.00 :	2-44
...	
-2.00 :	54-61
-4.00 :	55-63
-4.00 :	56-81
-9.00 :	57-64
-9.00 :	58-64
-5.00 :	58-75
-5.00 :	58-61
-9.00 :	59-64
-5.00 :	59-75
-5.00 :	59-61
-9.00 :	60-64
-5.00 :	60-75
-9.00 :	61-75
-4.00 :	61-76
-2.00 :	61-82
-2.00 :	61-83
-2.00 :	61-84
-6.00 :	61-63
-5.00 :	62-77
-4.00 :	63-77
-9.00 :	64-74
-9.00 :	64-75
-9.00 :	64-79
-9.00 :	64-73
-9.00 :	64-80
-9.00 :	64-82
-9.00 :	64-83
-9.00 :	64-84
-9.00 :	64-70
-9.00 :	64-71
-4.00 :	70-71
-9.00 :	73-78
-6.00 :	73-75
-6.00 :	73-76
-6.00 :	73-77
-9.00 :	73-81
-5.00 :	74-75
-9.00 :	75-78
-6.00 :	75-79
-6.00 :	75-80
-2.00 :	75-82
-2.00 :	75-83
-2.00 :	75-84
-9.00 :	76-78
-6.00 :	76-79
-2.00 :	76-82
-2.00 :	76-83
-2.00 :	76-84
-9.00 :	77-78
-6.00 :	77-79
-4.00 :	77-81
-9.00 :	78-80
-9.00 :	78-79
-9.00 :	79-81
-4.00 :	82-83
-4.00 :	82-84
-4.00 :	83-84

----

1 solutions with 2889.00 inconsistencies found.

Figure B.3: Pajek Result Report for SCS Features Classification at Number of Clusters = 1

(The original text file is one column content 1078 lines)

SCS Features Classification (Pajek Result Graph at Number of Clusters = 27)

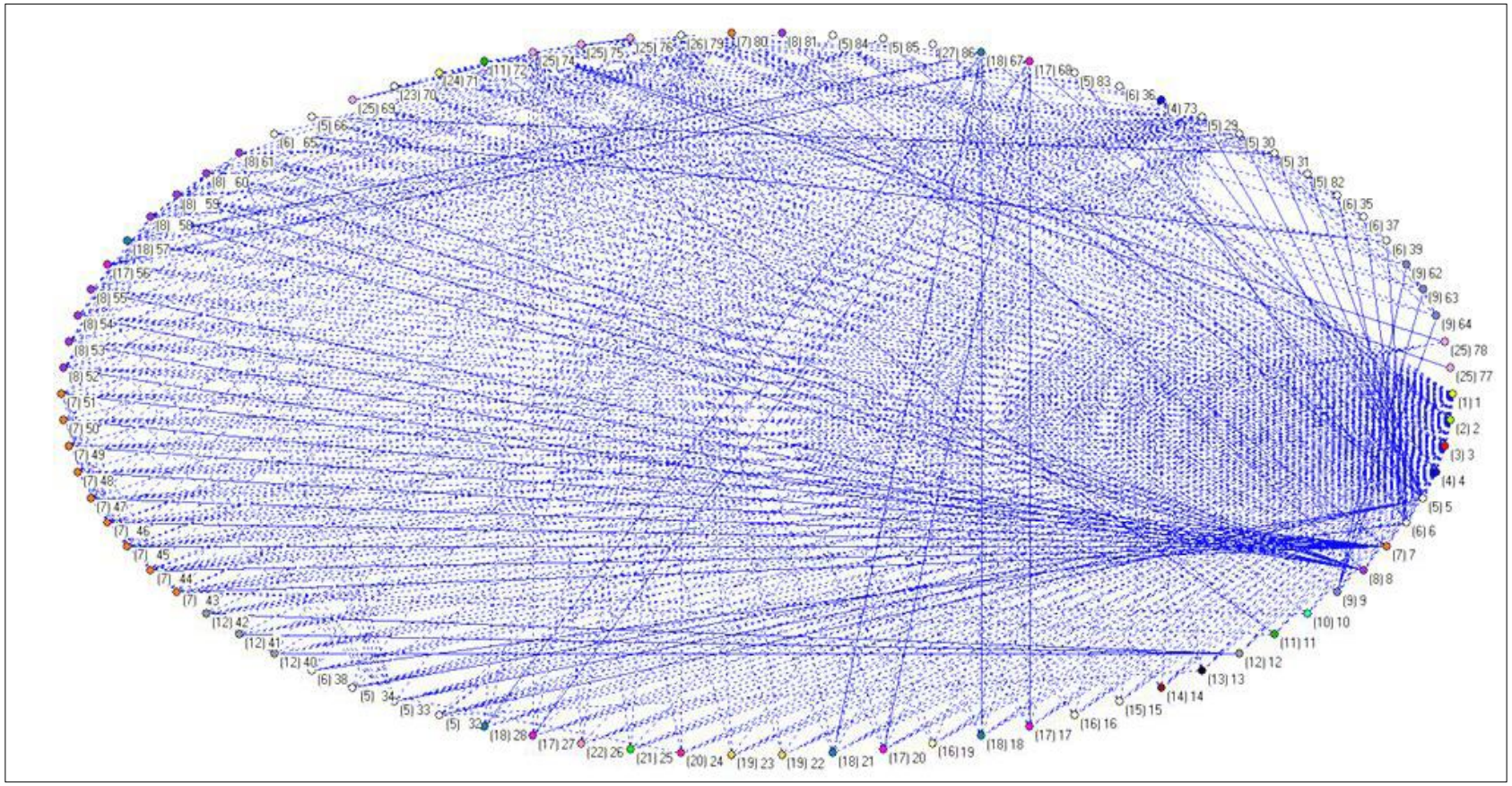

Figure B.4: SCS Features Classification (Pajek Result at Number of clusters = 27)

SCS Features Classification (Pajek Result Report at Number of Clusters = 27)

```
---------------------------------------------------------------------
Reading Network   ---   G:\Thesis\Thesis Experiments\SCS\SCS Pajek results\SCS-pacjek-data.net
---------------------------------------------------------------------
                Working...
            675 lines read.
          Time spent:  0:00:00
-----------------------------------------------------
Signed graphs: positive diagonal blocks,
    negative off-diagonal blocks
-----------------------------------------------------
                Working...
Number of clusters: 27, alpha: 0.500,
      min size of clusters: 1
------- Starting partition -------
     Errors:     332.00      Lines
-------------------------------------
      -4.00 :       1-37
      -4.00 :       1-50
      -5.00 :       1-52
      -8.00 :       2-7
      -8.00 :       2-14
      -8.00 :       2-57
      -4.00 :       3-16
      -4.00 :       3-32
      -4.00 :       3-60
      -8.00 :       4-11
      -8.00 :       4-61
      -5.00 :       11-61
      -5.00 :       22-75
      -4.00 :       27-70
      -5.00 :       28-75
      -9.00 :       31-67
      -4.00 :       39-40
      -4.00 :       51-54
      -9.00 :       64-79
       8.00 :       2-70
       8.00 :       2-71
       8.00 :       4-74
       3.00 :       5-68
       3.00 :       5-75
       3.00 :       5-76
       3.00 :       5-77
       3.00 :       5-29
       3.00 :       5-30
       3.00 :       5-78
       3.00 :       5-72
       3.00 :       6-81
       8.00 :       6-79
       8.00 :       6-73
       8.00 :       6-80
       8.00 :       6-32
       3.00 :       7-65
       3.00 :       7-36
       3.00 :       7-37
       3.00 :       7-38
       3.00 :       7-39
       3.00 :       7-40
       3.00 :       7-41
       3.00 :       7-42
       3.00 :       7-43
       3.00 :       7-44
       3.00 :       8-66
       3.00 :       8-45
       3.00 :       8-46
       3.00 :       8-47
       3.00 :       8-48
       3.00 :       8-51
       3.00 :       8-52
       3.00 :       8-54
       8.00 :       9-82
       8.00 :       9-84
       4.00 :       11-60
       3.00 :       12-35
       3.00 :       12-33
       3.00 :       12-34
       3.00 :       17-71
       3.00 :       18-70
       3.00 :       20-71
       3.00 :       21-70
       3.00 :       27-71
       3.00 :       28-70
       3.00 :       49-71
       3.00 :       50-70
       9.00 :       56-77
       1.00 :       57-61
       8.00 :       61-85
       5.00 :       61-62
       8.00 :       61-86
       1.00 :       62-63
-------------------------------------
------- Improvements -------
          1:     115.00
          2:     84.00
          5:     81.00
          17:     78.00
          26:     76.00
          93:     72.00
          636:     71.00
------- Final partition  1-------
     Errors:     71.00      Lines
-------------------------------------
      -4.00 :       82-84
       8.00 :       2-70
       8.00 :       2-71
       3.00 :       5-68
       3.00 :       5-29
       3.00 :       5-31
       3.00 :       5-78
       3.00 :       6-81
       3.00 :       7-36
       3.00 :       7-37
       3.00 :       7-38
       3.00 :       7-39
       3.00 :       8-51
       3.00 :       8-52
       3.00 :       8-53
       3.00 :       8-54
       8.00 :       9-83
       3.00 :       12-33
       1.00 :       62-63
-------------------------------------
1 solutions with 71.00 inconsistencies found.
          Time spent:  5:01:26
```

Figure B.5: Pajek Result Report for SCS Features Classification at Number of Clusters = 27

(The original text file is one column content 119 lines)

SCS Features Classification (Pajek Result Graph at Number of Clusters = 86)

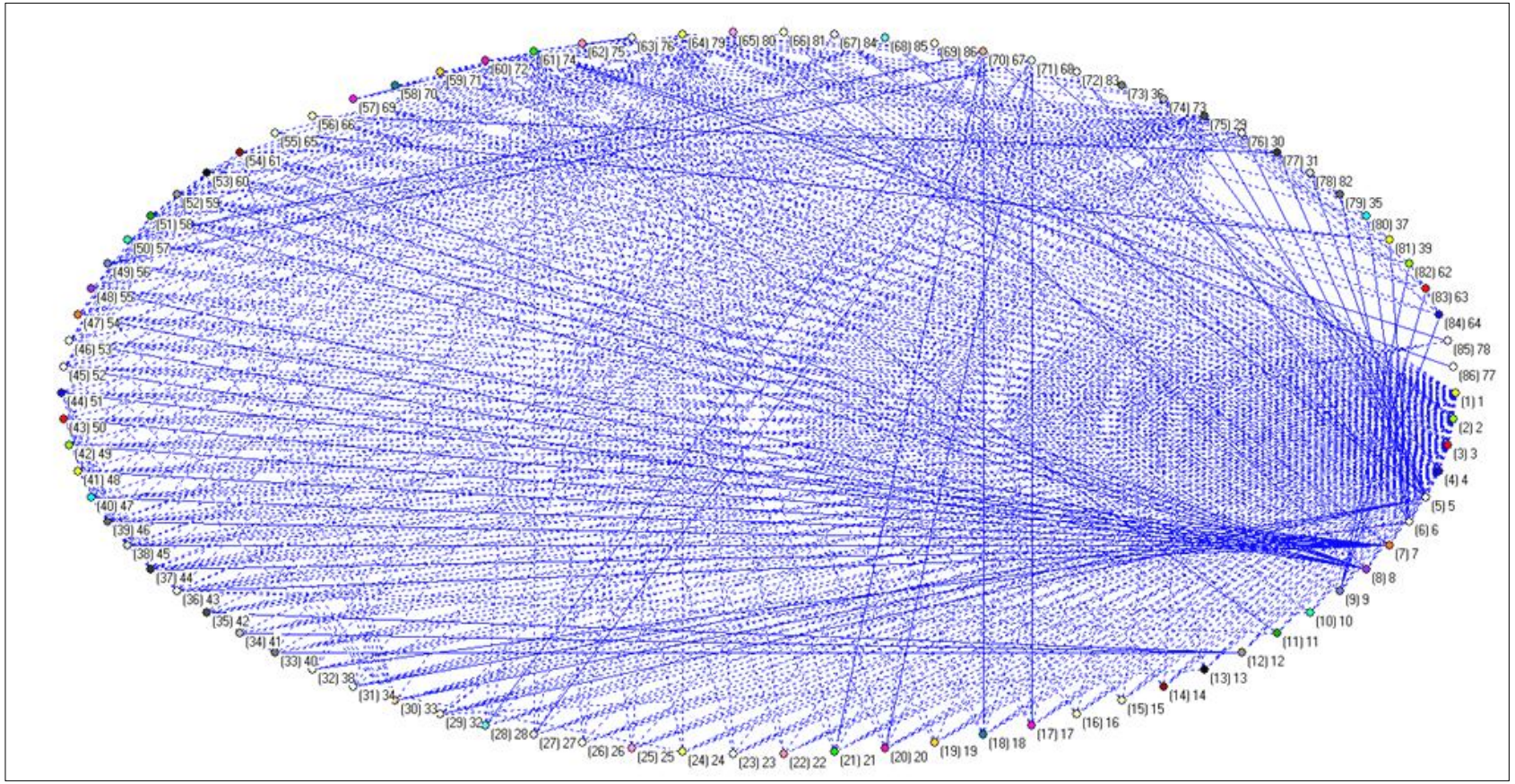

Figure B.6: SCS Features Classification (Pajek Result at Number of clusters = 86)

SCS Features Classification (Pajek Result Report at Number of Clusters = 86)

```
---------------------------------------------------------------------------
Reading Network   ---   G:\Thesis\Thesis Experiments\SCS\SCS Pajek results\SCS-pacjek-data.net
---------------------------------------------------------------------------
                Working...
Number of clusters: 86, alpha: 0.500,
        min size of clusters: 1
------- Starting partition -------
  Errors:    245.00      Lines
 ----------------------------------
    8.00 :     2-70
    8.00 :     2-71
    8.00 :     4-74
    3.00 :     5-68
    3.00 :     5-75
    3.00 :     5-76
    3.00 :     5-77
    3.00 :     5-29
    3.00 :     5-30
    3.00 :     5-31
    3.00 :     5-78
    3.00 :     5-72
    3.00 :     5-67
    3.00 :     6-81
    8.00 :     6-79
    8.00 :     6-73
    8.00 :     6-80
    8.00 :     6-32
    3.00 :     7-65
    3.00 :     7-36
    3.00 :     7-37
    3.00 :     7-38
    3.00 :     7-39
    3.00 :     7-40
    3.00 :     7-41
    3.00 :     7-42
    3.00 :     7-43
    3.00 :     7-44
    3.00 :     8-66
    3.00 :     8-45
    3.00 :     8-46
    3.00 :     8-47
    3.00 :     8-48
    3.00 :     8-51
    3.00 :     8-52
    3.00 :     8-53
    3.00 :     8-54
    8.00 :     9-82
    8.00 :     9-83
    8.00 :     9-84
    4.00 :    11-60
    3.00 :    12-35
    3.00 :    12-33
    3.00 :    12-34
    3.00 :    17-71
    3.00 :    18-70
    3.00 :    20-71
    3.00 :    21-70
    3.00 :    27-71
    3.00 :    28-70
    3.00 :    49-71
    3.00 :    50-70
    6.00 :    55-81
    9.00 :    56-77
    1.00 :    57-61
 ----------------------------------
------- Improvements -------
------- Final partition 1-------
  Errors:    245.00      Lines
 ----------------------------------
    8.00 :     2-70
    8.00 :     2-71
    8.00 :     4-74
    3.00 :     5-68
    3.00 :     5-75
    3.00 :     5-76
    3.00 :     5-77
    3.00 :     5-29
    3.00 :     5-30
    3.00 :     5-31
    3.00 :     5-78
    3.00 :     5-72
    3.00 :     5-67
    3.00 :     6-81
    8.00 :     6-79
    8.00 :     6-73
    8.00 :     6-80
    8.00 :     6-32
    3.00 :     7-65
    3.00 :     7-36
    3.00 :     7-37
    3.00 :     7-38
    3.00 :     7-39
    3.00 :     7-40
    3.00 :     7-41
    3.00 :     7-42
    3.00 :     7-43
    3.00 :     7-44
    3.00 :     8-66
    3.00 :     8-45
    3.00 :     8-46
    3.00 :     8-47
    3.00 :     8-48
    3.00 :     8-51
    3.00 :     8-52
    3.00 :     8-53
    3.00 :     8-54
    8.00 :     9-82
    8.00 :     9-83
    8.00 :     9-84
    4.00 :    11-60
    3.00 :    12-35
    3.00 :    12-33
    3.00 :    12-34
    3.00 :    17-71
    3.00 :    18-70
    3.00 :    20-71
    3.00 :    21-70
    3.00 :    27-71
    3.00 :    28-70
    3.00 :    49-71
    3.00 :    50-70
    6.00 :    55-81
    9.00 :    56-77
    1.00 :    57-61
    8.00 :    61-85
    5.00 :    61-62
    8.00 :    61-86
    1.00 :    62-63
 ----------------------------------
1 solutions with 245.00
inconsistencies found.
Time spent:  0:00:35
```

Figure B.7: Pajek Result Report for SCS Features Classification at Number of Clusters = 86

(The original text file is one column content 106 lines)

	1	2	3		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		84	85	86
Feature #	Cluster #																						
1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1
2	1	1	1		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		2	2	2
3	1	1	1		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3
4	1	1	1		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4
5	1	2	2		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		5	5	5
6	1	2	3		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		6	6	6
7	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		7	7	7
8	1	2	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		8	8	8
9	1	2	3		2	6	9	8	9	9	9	9	8	9	9	9	9	9	9		9	9	9
10	1	2	3		9	8	9	9	10	10	10	10	9	10	10	10	10	10	10		10	10	10
11	1	2	3		10	9	10	10	11	11	11	11	10	11	11	11	11	10	11		11	11	11
12	1	2	3		11	10	7	7	8	12	12	12	6	12	9	12	12	11	12		12	12	12
13	1	2	2		12	11	10	11	12	13	10	13	11	9	12	13	13	12	13		13	13	13
14	1	2	3		13	12	11	12	13	14	13	14	12	13	10	14	14	13	14		14	14	14
15	1	2	3		6	11	12	7	14	15	14	15	13	14	13	15	15	14	15		15	15	15
16	1	2	3		11	9	13	13	14	12	15	6	14	15	14	16	13	15	16		16	16	16
17	1	2	3	…	13	13	12	12	15	16	8	16	15	16	15	17	16	16	17	…	17	17	17
18	1	2	3		12	14	14	13	16	17	16	17	16	17	11	18	11	17	18		18	18	18
19	1	2	3		14	11	15	10	12	18	11	18	13	18	16	16	13	15	19		19	19	19
20	1	2	3		13	13	12	12	15	16	8	16	15	16	15	17	16	16	17		20	20	20
21	1	2	3		12	14	14	13	16	17	16	17	16	17	11	18	11	17	18		21	21	21
22	1	2	3		14	6	16	14	13	13	17	14	17	15	17	19	17	18	20		22	22	22
23	1	2	33		15	15	15	15	17	19	13	7	13	19	18	19	17	19	10		23	23	23
24	1	2	3		15	16	10	11	12	20	18	14	9	6	16	20	18	20	21		24	24	24
25	1	2	3		15	10	11	16	17	20	14	15	18	20	19	21	19	21	22		25	25	25
26	1	2	3		10	9	12	9	18	12	17	19	14	21	20	22	20	13	23		26	26	26
27	1	2	3		13	13	12	12	15	16	8	16	15	16	15	17	16	16	17		27	27	27
28	1	2	3		12	14	14	13	16	17	16	17	16	17	11	18	11	17	18		28	28	28
29	1	1	1		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		74	75	75
30	1	2	1		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		75	76	76
Error	2889	597	238		73	73	71	71	71	71	71	71	71	71	71	71	71	71	74		228	236	245
Solution	1	4	4		1	1	486	1086	2064	1230	2064	2621	671	2069	1513	1	2143	1430	5175		12	1	1

Table B.12: Part of Pajek's Clustering Results for SCS product line Features (features 1 to 30)

	1	2	3		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		84	85	86
Feature #	Cluster #																						
31	1	2	1		5	5	5	5	5	5	5	5	5	5	5	5	5	5	21		76	56	77
32	1	2	2		14	16	5	5	19	21	5	5	5	5	21	5	5	19	10		29	29	29
33	1	2	3		10	14	13	15	17	5	19	5	5	19	5	5	20	5	24		30	30	30
34	1	2	3		5	15	15	10	5	9	9	9	5	5	19	5	21	9	24		31	31	31
35	1	2	3		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		77	78	79
36	1	2	3		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		73	73	73
37	1	2	3		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		78	79	80
38	1	2	3		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		32	32	32
39	1	1	2		9	16	17	17	20	9	19	13	23	20	23	6	15	25	29		79	80	81
40	1	2	3		15	12	6	12	12	12	12	10	20	15	17	12	12	22	26		33	33	33
41	1	2	3		11	10	7	7	8	12	12	12	6	12	9	12	12	11	12		34	34	34
42	1	2	3		11	10	7	7	8	12	12	12	6	12	9	12	12	11	12		35	35	35
43	1	1	2		11	14	16	7	7	7	7	7	7	13	18	7	23	20	13		36	36	36
44	1	2	2		15	7	7	7	7	16	7	7	7	7	14	7	7	18	22		37	37	37
45	1	2	2		10	13	15	7	7	7	13	7	7	7	7	7	25	7	20		38	38	38
46	1	2	2		6	9	7	7	17	13	7	7	7	11	23	7	7	24	27		39	39	39
47	1	2	3	…	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	…	40	40	40
48	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		41	41	41
49	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		42	42	42
50	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		43	43	43
51	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		44	44	44
52	1	2	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		45	45	45
53	1	2	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		46	46	46
54	1	2	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		47	47	47
55	1	2	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		48	48	48
56	1	2	3		13	13	12	12	15	16	8	16	15	16	15	17	16	16	17		49	49	49
57	1	2	2		12	14	14	13	16	17	16	17	16	17	11	18	11	17	18		50	50	50
58	1	2	2		12	9	15	9	18	8	8	8	9	8	8	8	8	25	28		51	51	51
59	1	2	2		14	10	10	13	11	13	20	15	19	8	8	8	8	8	19		52	52	52
60	1	2	2		13	15	11	14	8	8	8	8	8	8	12	8	8	26	29		53	53	53
Error	2889	597	238		73	73	71	71	71	71	71	71	71	71	71	71	71	71	74		228	236	245
No Sol.	1	4	4		1	1	486	1086	2064	1230	2064	2621	671	2069	1513	1	2143	1430	5175		12	1	1

Table B.13: Part of Pajek's Clustering Results for SCS product line Features (features 31 to 60)

	1	2	3		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		84	85	86
Feature #	Cluster #																						
61	1	2	2		11	13	17	11	12	18	12	22	16	21	17	8	28	23	20		54	54	54
62	1	2	3		4	6	9	8	9	9	9	9	8	9	9	9	9	24	9		80	81	82
63	1	2	3		2	2	9	4	9	9	4	21	10	9	9	9	9	9	4		81	82	83
64	1	2	3		2	6	4	8	4	4	9	9	8	4	16	9	9	9	9		82	83	84
65	1	2	2		9	16	17	17	20	9	19	6	23	20	23	6	6	6	29		55	55	55
66	1	2	3		5	5	5	5	5	5	5	5	5	5	5	5	5	5	21		56	56	56
67	1	2	1		12	14	14	13	16	17	16	17	16	17	11	18	11	17	18		70	70	70
68	1	1	1		13	13	12	12	15	16	8	16	15	16	15	17	16	16	17		71	71	71
69	1	2	3		16	17	18	17	6	21	22	23	24	22	24	25	6	27	30		57	57	57
70	1	2	3		11	11	13	10	13	9	14	20	18	12	22	23	24	28	24		58	58	58
71	1	2	3		15	12	10	8	20	19	15	11	13	19	23	24	14	21	11		59	59	59
72	1	2	3		10	9	10	10	11	11	11	11	10	11	11	11	11	10	11		60	60	60
73	1	2	1		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	74	74
74	1	1	2		16	17	18	17	6	21	22	23	24	22	24	25	6	27	30		61	61	61
75	1	1	2	…	16	17	18	17	6	21	22	23	24	22	24	25	6	27	30	…	62	62	62
76	1	2	3		8	10	15	5	10	18	10	20	12	24	25	25	26	29	15		63	63	63
77	1	1	2		16	17	18	17	6	21	22	23	24	22	24	25	6	27	30		84	85	86
78	1	1	3		16	17	18	17	6	21	22	23	24	22	24	25	6	27	30		83	84	85
79	1	1	2		9	8	8	18	19	8	20	8	22	24	21	26	23	26	28		64	64	64
80	1	2	3		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7		65	65	65
81	1	1	3		8	8	8	8	8	8	8	8	6	8	8	8	8	8	8		66	66	66
82	1	1	2		10	4	2	3	3	1	14	1	3	4	4	5	3	13	11		56	77	78
83	1	1	3		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		72	72	72
84	1	1	2		11	5	5	5	18	5	5	5	11	18	5	5	5	5	5		67	67	67
85	1	1	2		5	5	5	5	5	11	5	9	3	5	13	5	5	24	5		68	68	68
86	1	1	3		14	12	13	19	11	9	21	15	24	25	26	27	15	15	27		69	69	69
error	2889	597	238		73	73	71	71	71	71	71	71	71	71	71	71	71	71	74		228	236	245
No. Sol.	1	4	4		1	1	486	1086	2064	1230	2064	2621	671	2069	1513	1	2143	1430	5175		12	1	1

Table B.14: Part of Pajek's Clustering Results for SCS product line Features (features 61 to 86)

SCS Features Reuse Opportunity

To compute *SCS* features *Reuse Opportunities* (FRO) we use *Table 5.26*; *Table B.1*; and *Table B.2*; information and *Chapter 3*, equations for computing *FT*, *MPPF*, and *DF*.

As we do for the previous case study we compute *FT, MPPF,* and *DF* based on equations (10) to (12); (15) to (19); and (4) to (9), and (25) respectively.

Table B.15; *Table B.16*; and *Table B.17*; show the results of the previous processes for each *SCS* feature.

Feature #	Features	FT	MPP Factors					Dependency Factors								FRO
			NA	PR	FC	FBTW	MPPF	FU	FMD	FSB	FEX	FCN	FSQ	DF	IDF	
1	Standard	1	1	0.0105354	1	1	0.75263384	0	1	20	38	0	0	0.6941176	0	2.44675149
2	Scientific	0.5	0.63	0.0184906	0.89	0.5	0.50962266	0	1	27	24	0	0	0.6117647	0	1.62138737
3	Programmer	0.5	0.57	0.0047302	0.44	0.5	0.37868254	0	0	19	26	0	0	0.5294118	0	1.40809431
4	Statistics	0.5	0.74	0.0172006	0.77	0.5	0.50680015	0	0	17	41	0	0	0.6823529	0.0119048	1.68915309
5	Display	1	1	0.0141905	1	1	0.75354762	4	0	10	0	0	0	0.1647059	0.1351351	1.91825351
6	Clearing	1	1	0.0116104	1	1	0.7529026	4	0	5	0	0	0	0.1058824	0.0632911	1.85878495
7	Systems	0.5	0.71	0.0043002	0.69	0.5	0.47607504	5	0	10	0	0	0	0.1764706	0.1333333	1.15254563
8	Size	0.5	0.65	0.0161256	1	1	0.66653139	5	0	9	0	0	0	0.1647059	0.1184211	1.33123727
9	Angle	0.25	0.24	0.0092453	0.83	0.5	0.39481133	2	0	3	3	0	0	0.0941176	0.0365854	0.73892898
10	Basic Notation	0.5	0.61	0.0129005	1	1	0.65572511	5	0	0	0	0	0	0.0588235	0	1.21454864
11	Scientific Notation	0.25	0.09	0.0141905	0.7	0.5	0.32604762	4	0	0	1	1	0	0.0705882	0.0119048	0.64663586
12	Memory	0.5	0.66	0.0163406	0.53	0.5	0.42658514	4	0	3	0	0	0	0.0823529	0.0365854	1.00893808
13	History	0.5	0.6	0.0027951	0.49	0.5	0.39819877	2	0	0	2	1	0	0.0588235	0	0.9570223
14	Binary Operations	1	1	0.0086003	1	1	0.75215008	4	0	0	1	2	0	0.0823529	0	1.83450302
15	Unique Operations	0.5	0.75	0.0178456	0.17	0.5	0.35946141	3	0	0	2	2	0	0.0823529	0	0.94181435
16	Exp Functions & Log	0.5	0.56	0.0141905	1	1	0.64354762	2	0	0	3	2	0	0.0823529	0	1.22590057
17	Ln	0.25	0.04	0.0154805	1	0.5	0.38887014	2	0	0	4	2	0	0.0941176	0	0.73298778
18	e Function	0.25	0.08	0.0118254	0.05	0.5	0.16045635	2	0	0	4	2	1	0.1058824	0	0.51633871
19	n!	0.25	0.27	0.0193507	0.26	0.5	0.26233767	2	0	0	3	2	0	0.0823529	0	0.59469061
20	SCTH Functions	0.25	0.01	0.0156955	1	1	0.50642389	2	0	0	4	2	0	0.0941176	0	0.85054153
21	SCTHI Functions	0.125	0.1	0.0045152	0.02	0.5	0.15612879	2	0	0	4	2	1	0.1058824	0	0.38701114
22	Basic Boolean Operation	0.5	0.75	0.0047302	1	1	0.68868254	2	0	0	3	2	0	0.0823529	0	1.27103548
23	Extra Boolean Operation	0.25	0.42	0.0208557	0.71	0.5	0.41271393	2	0	0	3	2	0	0.0823529	0	0.74506687
24	Statistics Operations	0.5	0.73	0.0081703	0.1	0.5	0.33454257	2	0	0	3	3	0	0.0941176	0	0.92866022
25	Percentage (%)	0.5	0.5	0.0090303	1	1	0.62725758	2	0	0	3	2	0	0.0823529	0	1.20961052
26	Mod	0.5	0.69	0.0122554	1	1	0.67556386	3	0	0	2	2	0	0.0823529	0	1.2579168
27	Int & Dms	0.25	0.22	0.0210707	0.41	0.5	0.28776768	2	0	0	4	2	0	0.0941176	0	0.63188533
28	Frac & Deg	0.25	0.09	0.0025801	0.06	0.5	0.16314502	2	0	0	4	2	1	0.1058824	0	0.51902738
29	Inputs Display	1	1	0.0159106	1	1	0.75397764	32	0	0	3	3	0	0.4470588	0.027027	2.20103646
30	Operations Results Display	1	1	0.0101054	1	1	0.75252634	4	0	0	2	1	0	0.0823529	0.027027	1.83487928

Table B.15: SCS Features FT, MPPF, DF, IDF, and FRO (features 1 to 30)

Feature #	Features	FT	MPP Factors					Dependency Factors								FRO
			NA	PR	FC	FBTW	MPPF	FU	FMD	FSB	FEX	FCN	FSQ	DF	IDF	
31	Error messages Display	0.5	0.5	0.0165556	0.78	0.5	0.44913889	2	0	0	3	2	0	0.0823529	0.027027	1.03149184
32	Operations History Display	0.5	0.69	0.0131155	0.44	0.5	0.41077886	3	0	0	2	1	0	0.0705882	0.0135135	0.9813671
33	Binary Numbers Display	0.5	0.63	0.0208557	0.77	0.5	0.48021393	5	0	0	3	5	0	0.1529412	0.0135135	1.13315511
34	Statistics Data Display	0.5	0.71	0.0094603	0.2	0.5	0.35486508	4	0	0	4	4	0	0.1411765	0.0135135	0.99604155
35	C	1	1	0.0206407	1	1	0.75516018	1	3	0	3	3	0	0.1176471	0.0253165	1.87280724
36	CE	0.5	0.74	0.0174156	0.38	0.5	0.4093539	1	3	0	4	3	0	0.1294118	0.0253165	1.03876567
37	Backspace	0.5	0.69	0.0135455	0.74	0.5	0.48588637	1	1	0	1	2	0	0.0588235	0.0126582	1.0447099
38	CAD	0.5	0.54	0.0174156	0.88	0.5	0.4843539	1	1	0	4	2	0	0.0941176	0.0126582	1.07847155
39	Error Clearing	1	1	0.0167706	1	1	0.75419265	2	0	0	2	2	1	0.0823529	0.0632911	1.83654559
40	Memory Store	0.5	0.59	0.0086003	1	1	0.64965008	5	0	0	1	1	0	0.0823529	0.0121951	1.23200302
41	Memory Recall	0.5	0.6	0.0139755	1	1	0.65349387	4	0	0	0	1	0	0.0588235	0.0121951	1.2123174
42	Memory Clear	0.5	0.67	0.0202107	1	1	0.67255268	4	1	0	1	1	0	0.0823529	0.0121951	1.25490562
43	Decimal	0.5	0.5	0.0105354	1	1	0.62763384	7	3	0	6	3	0	0.2235294	0.12	1.35116325
44	Binary	0.25	0.44	0.0169856	0.92	0.5	0.4692464	2	3	0	10	2	0	0.2	0.12	0.9192464
45	Octane	0.25	0.45	0.0077403	0.32	0.5	0.31943507	2	3	0	10	2	0	0.2	0.12	0.76943507
46	Hexadecimal	0.25	0.21	0.0068802	0.56	0.5	0.31922006	2	3	0	9	3	0	0.2	0.12	0.76922006
47	Binary number set	0.5	0.69	0.0178456	0.78	0.5	0.49696141	3	0	0	6	2	0	0.1294118	0.0666667	1.12637317
48	Octane number Set	0.5	0.6	0.0090303	0.1	0.5	0.30225758	3	0	0	6	2	0	0.1294118	0.0666667	0.93166934
49	Decimal Number Set	1	1	0.0045152	1	1	0.75112879	7	0	0	2	3	0	0.1411765	0.0666667	1.89230526
50	Decimal Point	1	1	0.0169856	1	1	0.7542464	5	0	0	4	2	0	0.1294118	0.0666667	1.88365816
51	Letter Numbers	0.5	0.73	0.0047302	0.24	0.5	0.36868254	3	0	0	6	2	0	0.1294118	0.0666667	0.99809431
52	Byte Number Set	0.5	0.6	0.0032251	1	1	0.65080628	3	0	0	6	3	0	0.1411765	0.0657895	1.29198275
53	Word Number Set	0.5	0.57	0.0150505	1	1	0.64626263	3	0	0	6	3	0	0.1411765	0.0657895	1.2874391
54	Dword Number Set	0.25	0.33	0.0163406	0.83	0.5	0.41908514	3	0	0	6	3	0	0.1411765	0.0657895	0.81026161
55	Qword Number Set	0.25	0.09	0.0032251	0.59	0.5	0.29580628	3	0	0	6	3	0	0.1411765	0.0657895	0.68698275
56	Pi	0.5	0.5	0.0113954	1	1	0.62784885	2	0	0	4	1	0	0.0823529	0	1.21020179
57	2Pi	0.25	0.09	0.0043002	0.68	0.5	0.31857504	2	0	0	4	1	1	0.0941176	0	0.66269268
58	Byte	0.5	0.51	0.0124704	1	1	0.63061761	4	4	0	6	2	0	0.1882353	0.1052632	1.3188529
59	Word	0.5	0.67	0.0079553	1	1	0.66948882	4	4	0	6	2	0	0.1882353	0.1052632	1.35772411
60	Dword	0.25	0.07	0.0180606	0.4	0.5	0.24701516	4	4	0	6	2	0	0.1882353	0.1052632	0.68525045

Table B.16: SCS Features FT, MPPF, DF, IDF, and FRO (features 31 to 60)

Feature #	Features	FT	MPP Factors					Dependency Factors								FRO
			NA	PR	FC	FBTW	MPPF	FU	FMD	FSB	FEX	FCN	FSQ	DF	IDF	
61	Qword	0.25	0.03	0.0068802	0.92	0.5	0.36422006	2	4	0	8	2	0	0.1882353	0.1052632	0.80245535
62	Degrees	0.5	0.65	0.0032251	1	1	0.66330628	1	3	0	2	1	0	0.0823529	0.0365854	1.24565922
63	Radians	0.25	0.08	0.0058052	0.98	0.5	0.3914513	1	3	0	2	1	0	0.0823529	0.0365854	0.72380424
64	Grads	0.25	0.15	0.0036551	0.73	0.5	0.34591378	1	3	0	2	1	0	0.0823529	0.0365854	0.67826672
65	Enable Calculator Functions	0.5	0.61	0.0060202	1	1	0.65400505	1	0	0	1	0	0	0.0235294	0.0126582	1.17753446
66	Disable Calculator Functions	0.25	0.44	0.0184906	0.81	0.5	0.44212266	1	0	0	1	1	0	0.0352941	0.027027	0.72741678
67	Inverse-On	0.5	0.52	0.0103204	0.7	0.5	0.43258009	1	0	4	5	1	0	0.1294118	0.0493827	1.06199186
68	Inverse--Off	0.25	0.27	0.0049452	1	1	0.56873629	1	0	4	5	1	0	0.1294118	0.0493827	0.94814806
69	Equal	1	1	0.0021501	1	1	0.75053752	3	0	0	1	1	1	0.0705882	0.0125	1.82112575
70	Sign	1	1	0.0090303	1	1	0.75225758	5	0	0	0	1	0	0.0705882	0	1.82284581
71	Arcs	0.5	0.58	0.0043002	0.7	0.5	0.44607504	3	0	0	2	1	0	0.0705882	0	1.01666327
72	Scientific Notation Editing	0.5	0.5	0.0210707	0.81	0.5	0.45776768	2	0	0	2	2	0	0.0705882	0.0119048	1.02835592
73	Add	0.5	0.65	0.0083853	1	1	0.66459632	1	0	0	0	3	0	0.0470588	0.0119048	1.21165515
74	Result Foundation	1	1	0.0154805	1	1	0.75387014	4	0	2	1	17	1	0.2941176	0.0375	2.04798778
75	Unexpected Input Handling	0.5	0.58	0.0109654	0.95	0.5	0.51024135	1	0	0	0	0	1	0.0235294	0.025	1.03377076
76	Error Notification	1	1	0.0199957	1	1	0.75499892	4	1	0	2	0	1	0.0941176	0.025	1.84911657
77	Parsing	0.5	0.7	0.0043002	1	1	0.67607504	1	0	0	0	0	0	0.0117647	0.0125	1.18783974
78	Number Conversion	0.5	0.6	0.0189207	1	1	0.65473017	1	0	0	0	0	0	0.0117647	0.0125	1.16649487
79	Calc Buttons	1	1	0.0161256	1	1	0.75403139	40	0	0	0	40	0	0.9411765	0	2.69520786
80	Systems Selection Button	0.5	0.63	0.0081703	0.24	0.5	0.34454257	5	0	0	3	4	0	0.1411765	0.1066667	0.98571904
81	Size Selection Button	0.5	0.63	0.0182756	0.57	0.5	0.42956891	5	0	0	3	4	0	0.1411765	0.1052632	1.07074538
82	Display Box	1	1	0.0133305	1	1	0.75333262	6	0	0	0	6	0	0.1411765	0.0810811	1.89450909
83	History Dialog Box	0.25	0.16	0.0105354	0.19	0.5	0.21513384	2	0	0	2	2	0	0.0705882	0.027027	0.53572208
84	Statistics Dialog Box	0.25	0.44	0.0086003	0.98	0.5	0.48215008	4	0	0	3	3	0	0.1176471	0.027027	0.84979713
85	Binary Numbers Dialog Box	0.25	0.11	0.0043002	0.44	0.5	0.26357504	5	0	0	3	5	0	0.1529412	0.027027	0.66651621
86	Menu	0.5	0.53	0.0060202	0.78	0.5	0.45400505	5	0	0	0	0	0	0.0588235	0	1.01282858

Table B.17: SCS Features FT, MPPF, DF, IDF, and FRO (features 61 to 86)

SCS Features Sets Options Analysis

In this section we compute *SCS Features Sets Options Prices* as had been done in *Chapter 5*, except that we use *S = X = FSRO(Features Set)*, instead of using *X = FSRO(System Reuse Opportunity)*. The results of these computations and *SCS Features Sets Development Priorities* are shown in *Table B.18*; and *Figure B.8*; shows the relation between *SCS Features Sets Reuse Opportunities* and theirs *Options Prices*.

From these calculations it is appeared that like the computations results when *X = FSRO(System)*, here with *S = X = FSRO(Features Set)*, the *Features Set* with *largest Reuse opportunity* has the *largest Call Option Price*. Other thing is noticed from results shown in *Table B.18;* that the *difference* between *Call Option Price* and *Put Option Price* has a *positive relationship* with *Features Sets Reuse Opportunity*, i.e. *Features set* that has the *largest Reuse Opportunity*, also has the *largest difference* between its *Call* and *Put Prices*.

Features Set #	***Features Set Name***	***Options ROFS***	***Option Price***			***Development Priority***
			Call	**Put**	**Option Value**	
26	Calc Buttons	1.91089414	1.03887116	0.60137498	1.07107673	1st
1	Standard	1.868320117	1.015725493	0.58797656	1.047213538	2nd
14	Binary Operations	1.765875565	0.96003079	0.55573637	0.98979226	3rd
23	Sign	1.76402228	0.95902324	0.55515313	0.98875348	4th
25	Result Foundation	1.49688925	0.81379446	0.47108404	0.83902254	5th
6	Clearing	1.394075042	0.75789879	0.43872752	0.78139407	6th
5	Display	1.294759815	0.70390536	0.40747216	0.72572681	7th
4	Statistics	1.20329861	0.65418183	0.37868852	0.67446183	8th
22	Mod	1.18928935	0.64656560	0.37427969	0.66660948	9th
10	Basic Notation	1.165529034	0.63364813	0.36680211	0.65329157	10th
21	Percentage (%)	1.14098307	0.62030354	0.35907728	0.63953329	11th
12	Memory	1.139355712	0.61941882	0.35856514	0.63862114	12th
7	Systems	1.122574416	0.61029555	0.35328392	0.62921505	13th
2	Scientific	1.111583446	0.60432023	0.34982496	0.62305449	14th
8	Size	1.021212674	0.55518952	0.32138450	0.57240070	15th
3	Programmer	0.966917836	0.52567174	0.30429744	0.54196786	16th
27	Menu	0.96380897	0.52398159	0.30331905	0.54022531	17th
24	Arcs	0.95783974	0.52073638	0.30144048	0.53687949	18th
19	Boolean Operations	0.95314922	0.51818634	0.29996434	0.53425040	19th
13	History	0.908002696	0.49364211	0.28575633	0.50894529	20th
15	Unique Operations	0.873186896	0.47471425	0.27479950	0.48943066	21st
16	Exp Functions	0.855393627	0.46504082	0.26919980	0.47945734	22nd
20	Statistics Operations	0.85022885	0.46223295	0.26757440	0.47656242	23rd
17	Inverse-Off	0.85005186	0.46213673	0.26751870	0.47646322	24th
9	Angle	0.793843174	0.43157848	0.24982934	0.44495765	25th
11	Scientific Notation	0.786468812	0.42756935	0.24750856	0.44082424	26th
18	Inverse-On	0.60314268	0.32790280	0.18981424	0.33806797	27th

Table B.18: Development Priority of SCS Features Sets

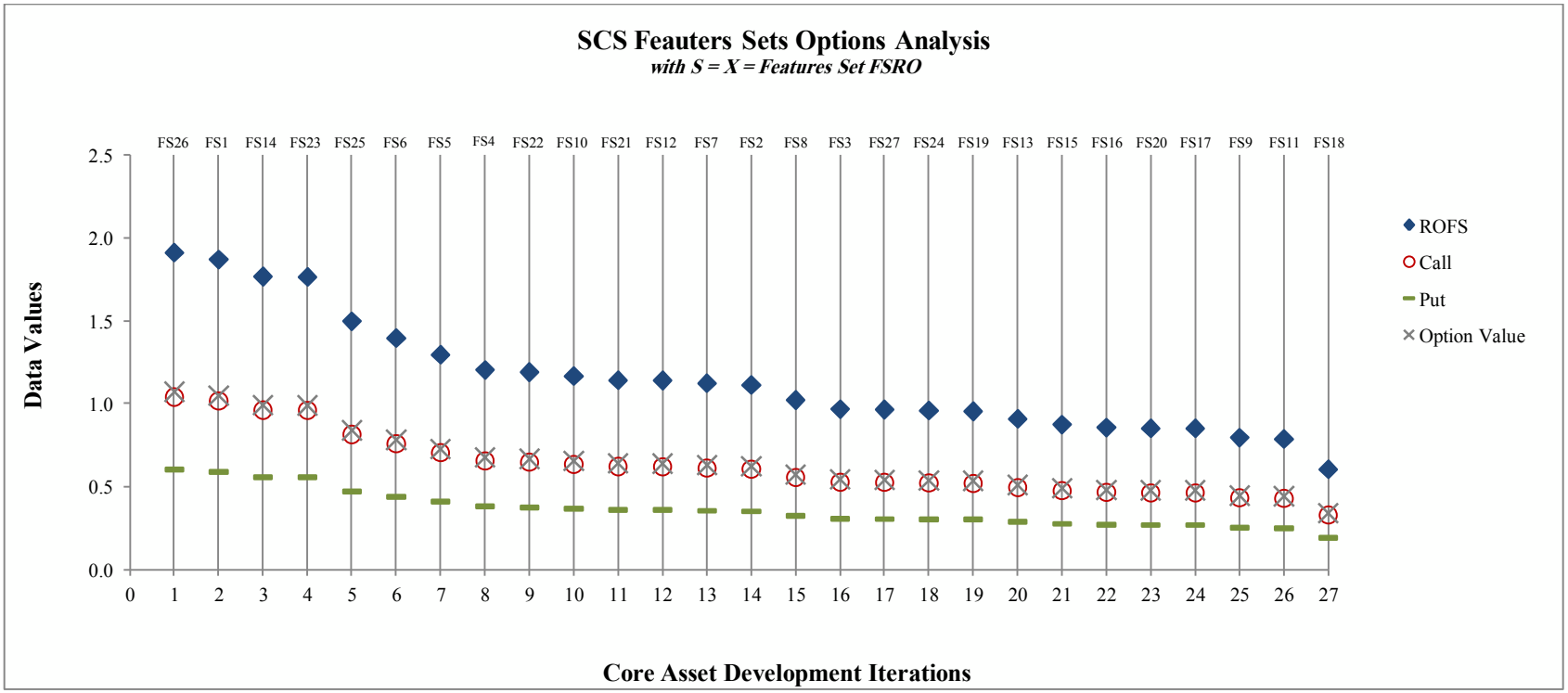

Figure B.8: SCS Features Sets Options Analysis

SCS Features Options Analysis

In this section we compute *SCS Features Options Prices* as had been done in *Chapter 5*, except that we use *S = X = FRO(Feature)*, instead of using *X = FRO(System Reuse Opportunity)*. The results of these computations and *SCS Features Development Priorities* are shown in *Table B.19*; and *Table B.20*; and *Figure B.9*; and *Figure B.10*; shows the relation between *SCS* features *Reuse Opportunities* and theirs *Options Prices*.

From these calculations it is appeared that like the computations results when *X = FRO(System)*, here with *S = X = FRO(Feature)*, the feature with *largest Reuse Opportunity* has the *largest Call Option Price*. Other thing is noticed from results shown in *Table B.19*; and *Table B.20;* that the *difference* between *Call Option Price* and *Put Option Price* has a *positive relationship* with feature *Reuse Opportunity*, i.e. feature that has the *largest Reuse Opportunity*, also has the *largest difference* between its *Call* and *Put Prices*.

Feature #	Features	Options	Option Price			Development Priority
		ROFS	Call	Put	Option Value	
79	Calc Buttons	2.6952079	2.272901	0.729665	2.272939	1st
1	Standard	2.4467515	2.063375	0.662401	2.063409	2nd
29	Inputs Display	2.2010365	1.85616	0.59588	1.856191	3rd
74	Result Foundation	2.0479878	1.727092	0.554445	1.727121	4th
5	Display	1.9182535	1.617686	0.519323	1.617713	5th
82	Display Box	1.8945091	1.597662	0.512894	1.597689	6th
49	Decimal Number Set	1.8923053	1.595804	0.512298	1.59583	7th
50	Decimal Point	1.8836582	1.588511	0.509957	1.588538	8th
35	C	1.8728072	1.579361	0.507019	1.579387	9th
6	Clearing	1.858785	1.567535	0.503223	1.567562	10th
76	Error Notification	1.8491166	1.559382	0.500605	1.559408	11th
39	Error Clearing	1.8365456	1.548781	0.497202	1.548807	12th
30	Operations Results Display	1.8348793	1.547376	0.496751	1.547401	13th
14	Binary Operations	1.834503	1.547058	0.496649	1.547084	14th
70	Sign	1.8228458	1.537228	0.493493	1.537253	15th
69	Equal	1.8211258	1.535777	0.493028	1.535803	16th
4	Statistics	1.6891531	1.424483	0.457299	1.424507	17th
2	Scientific	1.6213874	1.367335	0.438953	1.367358	18th
3	Programmer	1.4080943	1.187463	0.381209	1.187482	19th
59	Word	1.3577241	1.144985	0.367572	1.145004	20th
43	Decimal	1.3511633	1.139452	0.365796	1.139471	21st
8	Size	1.3312373	1.122648	0.360402	1.122667	22nd
58	Byte	1.3188529	1.112204	0.357049	1.112223	23rd
52	Byte Number Set	1.2919827	1.089544	0.349774	1.089563	24th
53	Word Number Set	1.2874391	1.085713	0.348544	1.085731	25th
22	Basic Boolean Operation	1.2710355	1.071879	0.344103	1.071897	26th
26	Mod	1.2579168	1.060816	0.340552	1.060834	27th
42	Memory Clear	1.2549056	1.058277	0.339737	1.058294	28th
62	Degrees	1.2456592	1.050479	0.337233	1.050497	29th
40	Memory Store	1.232003	1.038963	0.333536	1.03898	30th
16	Exp Functions & Log	1.2259006	1.033817	0.331884	1.033834	31st
10	Basic Notation	1.2145486	1.024243	0.328811	1.02426	32nd
41	Memory Recall	1.2123174	1.022362	0.328207	1.022379	33rd
73	Add	1.2116551	1.021803	0.328028	1.02182	34th
56	Pi	1.2102018	1.020578	0.327634	1.020595	35th
25	Percentage (%)	1.2096105	1.020079	0.327474	1.020096	36th
77	Parsing	1.1878397	1.001719	0.32158	1.001736	37th
65	Enable Calculator Functions	1.1775345	0.993029	0.31879	0.993045	38th
78	Number Conversion	1.1664949	0.983719	0.315801	0.983735	39th
7	Systems	1.1525456	0.971955	0.312025	0.971972	40th
33	Binary Numbers Display	1.1331551	0.955603	0.306775	0.955619	41st
47	Binary number set	1.1263732	0.949884	0.304939	0.9499	42nd
38	CAD	1.0784715	0.909488	0.291971	0.909503	43rd

Table B.19: Options Prices and Development Priorities of SCS's Features (from 1st to 43rd)

Feature #	Features	Options	Option Price			Development Priority
		ROFS	Call	Put	Option Value	
81	Size Selection Button	1.0707454	0.902972	0.28988	0.902987	44th
67	Inverse-On	1.0619919	0.89559	0.28751	0.895605	45th
37	Backspace	1.0447099	0.881016	0.282831	0.881031	46th
36	CE	1.0387657	0.876003	0.281222	0.876018	47th
75	Unexpected Input Handling	1.0337708	0.871791	0.279869	0.871806	48th
31	Error messages Display	1.0314918	0.869869	0.279253	0.869884	49th
72	Scientific Notation Editing	1.0283559	0.867225	0.278404	0.867239	50th
71	Arcs	1.0166633	0.857364	0.275238	0.857379	51th
86	Menu	1.0128286	0.85413	0.2742	0.854145	52th
12	Memory	1.0089381	0.850849	0.273147	0.850864	53th
51	Letter Numbers	0.9980943	0.841705	0.270211	0.841719	54th
34	Statistics Data Display	0.9960416	0.839974	0.269655	0.839988	55th
80	Systems Selection Button	0.985719	0.831269	0.266861	0.831282	56th
32	Operations History Display	0.9813671	0.827599	0.265682	0.827612	57th
13	History	0.9570223	0.807068	0.259092	0.807082	58th
68	Inverse--Off	0.9481481	0.799585	0.256689	0.799598	59th
15	Unique Operations	0.9418143	0.794243	0.254974	0.794256	60th
48	Octane number Set	0.9316693	0.785688	0.252228	0.785701	61st
24	Statistics Operations	0.9286602	0.78315	0.251413	0.783163	62nd
44	Binary	0.9192464	0.775211	0.248865	0.775224	63rd
20	SCTH Functions	0.8505415	0.717272	0.230264	0.717284	64th
84	Statistics Dialog Box	0.8497971	0.716644	0.230063	0.716656	65th
54	Dword Number Set	0.8102616	0.683303	0.21936	0.683315	66th
61	Qword	0.8024554	0.67672	0.217246	0.676731	67th
45	Octane	0.7694351	0.648874	0.208307	0.648885	68th
46	Hexadecimal	0.7692201	0.648692	0.208249	0.648703	69th
23	Extra Boolean Operation	0.7450669	0.628324	0.20171	0.628334	70th
9	Angle	0.738929	0.623148	0.200048	0.623158	71st
17	Ln	0.7329878	0.618137	0.198439	0.618148	72nd
66	Disable Calculator Functions	0.7274168	0.613439	0.196931	0.613449	73rd
63	Radians	0.7238042	0.610393	0.195953	0.610403	74th
55	Qword Number Set	0.6869827	0.579341	0.185985	0.57935	75th
60	Dword	0.6852505	0.57788	0.185516	0.57789	76th
64	Grads	0.6782667	0.57199	0.183625	0.572	77th
85	Binary Numbers Dialog Box	0.6665162	0.562081	0.180444	0.56209	78th
57	2Pi	0.6626927	0.558857	0.179409	0.558866	79th
11	Scientific Notation	0.6466359	0.545316	0.175062	0.545325	80th
27	Int & Dms	0.6318853	0.532876	0.171068	0.532885	81st
19	n!	0.5946906	0.50151	0.160999	0.501518	82nd
83	History Dialog Box	0.5357221	0.451781	0.145034	0.451788	83rd
28	Frac & Deg	0.5190274	0.437702	0.140515	0.437709	84th
18	e Function	0.5163387	0.435435	0.139787	0.435442	85th
21	SCTHI Functions	0.3870111	0.326371	0.104774	0.326377	86th

Table B.20: Options Prices and Development Priorities of SCS's Features (from 44th to 86th)

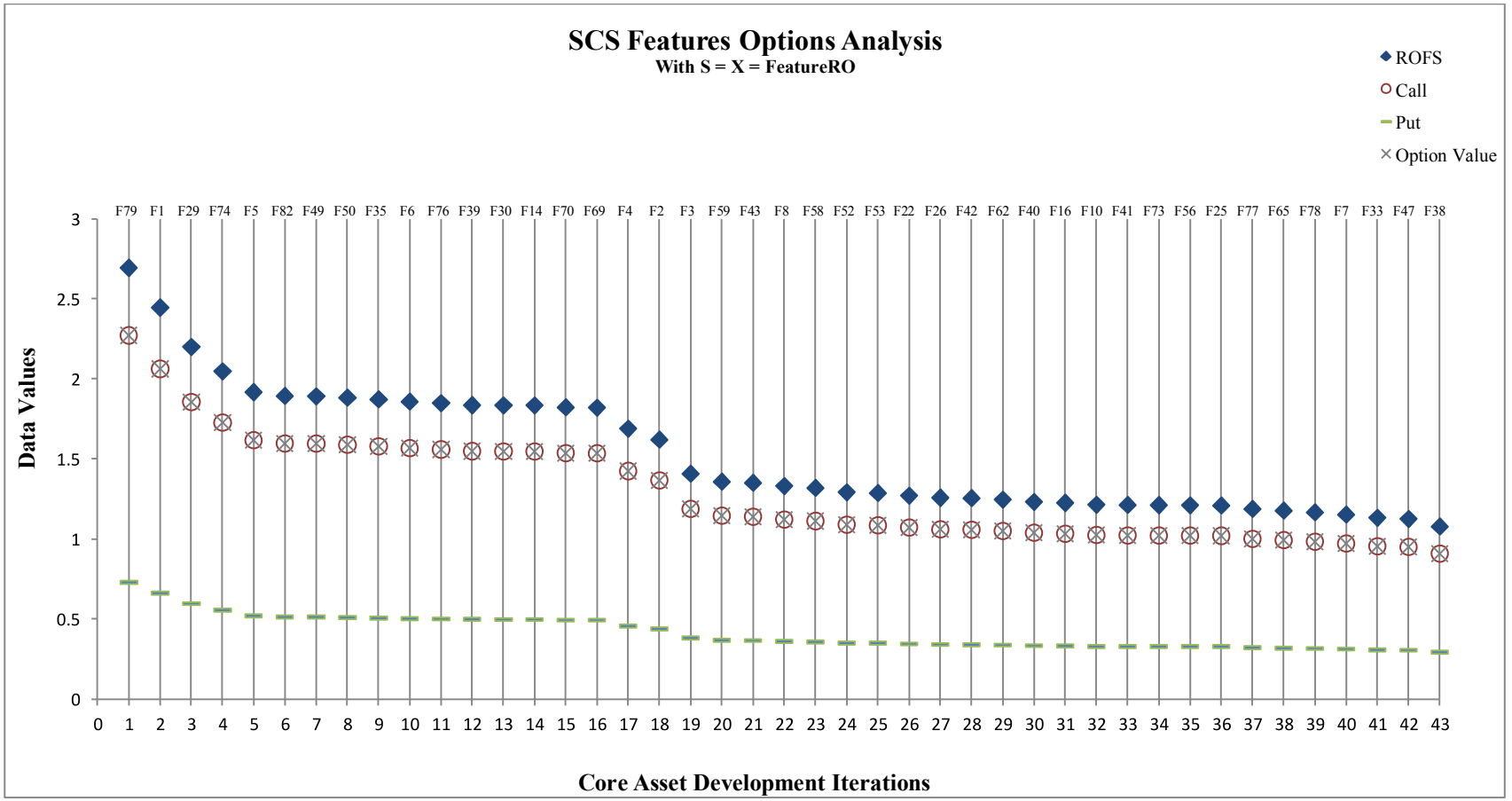

Figure B.9: SCS Features Options Analysis (Features from 1st to 43rd)

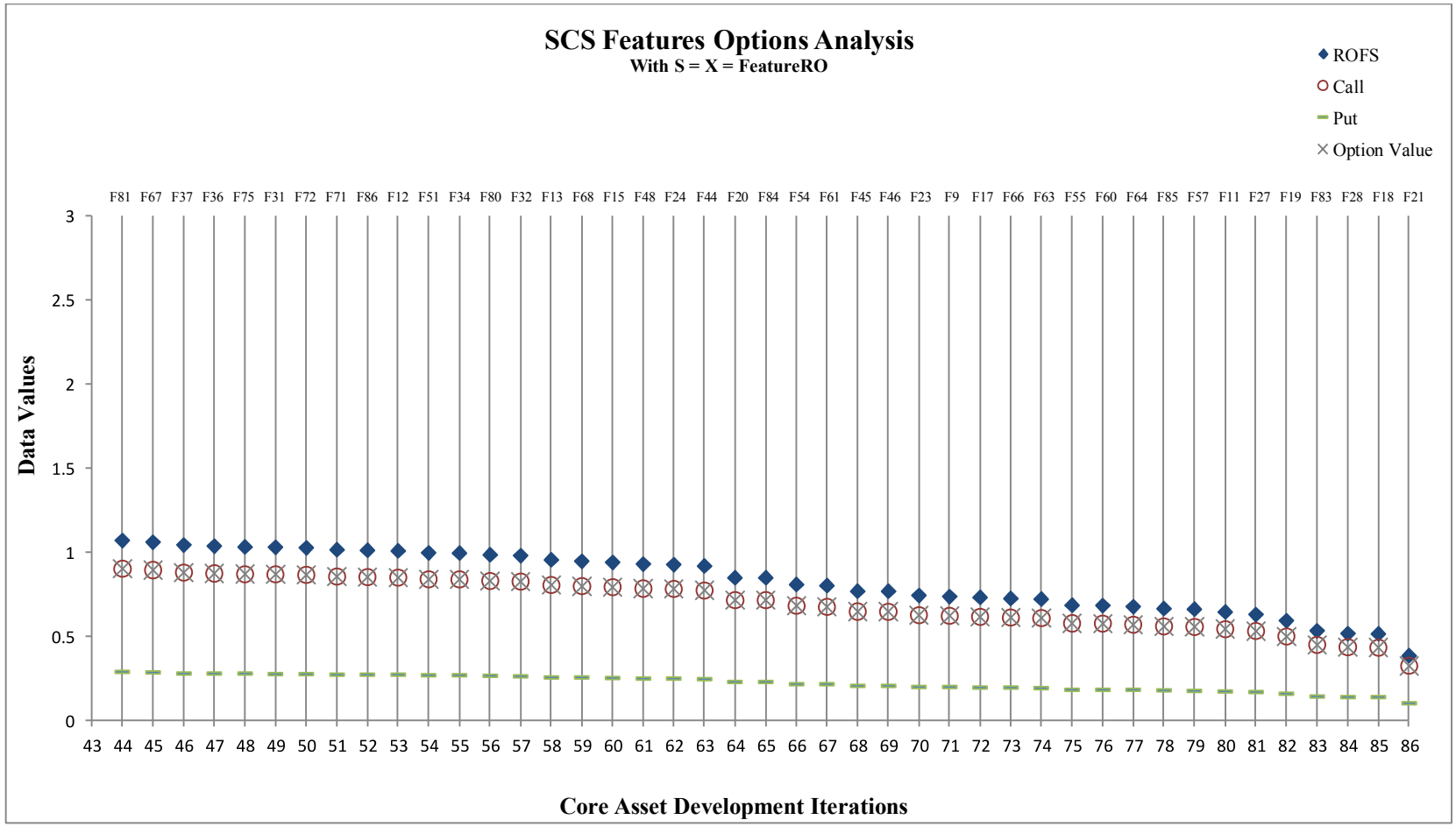

Figure B.10: SCS Features Options Analysis (Features from 44th to 86th)

Vitae

Personal Information

Name : KHALID MOHAMMED HUSSEIN AL-KAHSAH

Nationality : Yemeni

Date of Birth: 23/7/1878

Contact Information

Home Address: Omer Bin Abdul-Aziz Street – Thamar – Yemen.

Job Address : Mathematics & Computer Science Dep. - Collage of Science – Ibb University – Ibb – Yemen.

P. O. Box : 70270 – Ibb University, Ibb, Yemen.

Email : kkahsah@hotmail.com
kkahsah@gmail.com

Phone No. : 00967771006574 (Yemen)
00967733006574 (Yemen)

Educational Background

- M.Sc. in Computer Science, KFUPM, Dhahran, Saudi Arabia, 2012.
- B.Sc. in Computer Science, University of Basrah, Basrah, Iraq, 2001.

Academic Background

- Lecturer in Mathematics & Computer Science Dep., Collage of Science, Ibb University, Ibb, Yemen [2012 - …]
- Part time Lab. Assistant in ICS Dep. and Prep. Year Program, KFUPM, Dhahran, Saudi Arabia, [2006 – 2010]. (some semesters)
- Part Time Assistant in ABET Standing Committee, ICS Dep. KFUPM, Dhahran, Saudi Arabia, [2006 – 2010]. (some semesters).
- Graduate Assistant in Mathematics & Computer Science Dep., Collage of Science, Ibb University, Ibb, Yemen [2001 – 2005].
- Instructor in National University, Ibb, Yemen [2002 – 2003].
- Instructor in National Institute of Administrative Sciences, Ibb, Yemen [2001 – 2003].
- Teacher in many private institutes for Computer Skills and Programming Languages [2001 - 2005].

Research Interests

- Software Engineering, Software Product Line Engineering, Artificial Intelligent, Arabic Characters Recognition, Fuzzy Logic, Fuzzy Control, and Cryptography.
- I have done many scientific projects and papers (some of them are published) [2000 – 2012].